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**ROME AIR DEVELOPMENT CENTER  
AIR FORCE**

# **TECHNICAL OBJECTIVE DOCUMENT**

**FY - 89**



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**AIR FORCE SYSTEMS COMMAND  
UNITED STATES AIR FORCE**

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<p>This TOD describes the technical programs of the Rome Air Development Center in support of the Air Force Command, Control, Communications, and Intelligence (C3I) mission. The technical objectives have been aligned with the VANGUARD mission areas of Command, Control, and Communications (C3), Reconnaissance and Intelligence, Strategic Systems (Defense) and Technology as a means of focusing the RADC support of VANGUARD. This document is prepared to provide industry and universities with the midterm technical objectives in these areas.</p>					
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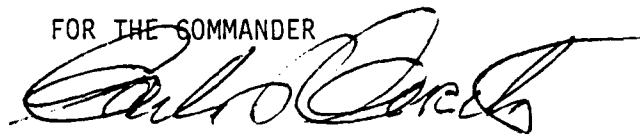
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FOR THE COMMANDER



CARLO P. CROCETTI  
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## INTRODUCTION

The Air Force Technical Objective Document (TOD) program is an integral part of the process by which the Air Force plans and formulates a detailed technology program to support the development and acquisition of Air Force weapon systems.

Each Air Force laboratory annually prepares its science and technology (S&T) program in response to available guidance based on USAF requirements, the identification of scientific and technological opportunities, and the needs of present and projected systems. These plans include proposed efforts to achieve desired capabilities, to resolve known technical problems, and to capitalize on new technical opportunities. The proposed efforts undergo a lengthy program formulation and review process. Generally, the criteria applied during the formulation and review are responsiveness to stated objectives and known requirements, scientific content and merit, program balance, developmental and life cycle costs, and consideration of payoff versus risk.

It is fully recognized that the development and accomplishment of the Air Force technical program are products of the teamwork on the part of the Air Force laboratories, and the industrial and academic research and development community. The TOD program is designed to provide to the industry and academic community, necessary information on the Air Force laboratories' planned technology programs. Each laboratory's TOD is extracted from its S&T Plan.

Specific objectives are:

- a. To provide planning information for independent research and development programs.
- b. To improve the quality of the unsolicited proposals and R&D procurements.
- c. To encourage face-to-face discussions between non-Government scientists and engineers and their Air Force counterparts.

One or more TODs have been prepared by each Air Force laboratory that has responsibility for a portion of the Air Force S&T program. Classified and limited distribution TODs are available from the Defense Technical Information Center (DTIC) and unclassified/unlimited TODs are available from the National Technical Information Service (NTIS).

As you read through the pages that follow, you may see a field of endeavor where your organization can contribute to the achievement of a specific technical goal. If such is the case, you are invited to discuss the objective further with the scientist or engineer identified with that objective. Further, you may have completely new ideas not considered in

this document which, if brought to the attention of the proper organization, can make a significant contribution to our military technology. We will always maintain an open mind in evaluating any new concepts which, when successfully pursued, would improve our future operational capability.

On behalf of the United States Air Force, you are invited to study the objectives listed in this document and to discuss them with the responsible Air Force personnel. Your ideas and proposals, whether in response to the TODs or not, are most welcome.



## HOW TO USE THIS DOCUMENT

Unsolicited proposals to conduct programs leading to the attainment of any of the objectives presented in this document may be submitted directly to an Air Force laboratory. However, before submitting a formal proposal, we encourage you to discuss your approach with the laboratory point of contact. After your discussion or correspondence with the laboratory personnel, you will be better prepared to write your proposal.

As stated in the AFSC Pamphlet 70-5, Contracting and Acquisition Unsolicited Proposals" Guide (copies of this informative guide on unsolicited proposals are available by writing to Air Force Systems Command/KCP, Andrews Air Force Base, Washington, DC 20334), elaborate brochures or presentations are definitely not desired. The "ABCs" of successful proposals are accuracy, brevity, and clarity. It is extremely important that your letter be prepared to encourage its reading, to facilitate its understanding, and to impart an appreciation of the ideas you desire to convey. Specifically, your letter should include the following:

1. Name and address of your organization.
2. Type of Organization (Profit, Nonprofit).
3. Concise title and abstract of the proposed research and the statement indicating that the submission is an unsolicited proposal.
4. An outline and discussion of the purpose of the research, the method of attack upon the problem, and the nature of the expected results.
5. Name and research experience of the principal investigator.
6. A suggestion as to the proposed starting and completion dates.
7. An outline of the proposed budget, including information on equipment, facility, and personnel requirements.
8. Names of any other Federal agencies receiving the proposal (this is extremely important).
9. Brief description of your facilities, particularly those which would be used in your proposed research effort.
10. Brief outline of your previous work and experience in the field.
11. If available, you should include a description brochure and a financial statement.

## CENTER MISSION

The Rome Air Development Center (RADC) is the Air Force Systems Command technology center for Command, Control, Communications and Intelligence (C3I). RADC plans and executes research, exploratory, and advanced development and selected acquisition programs in support of Air Force C3I and Computational Sciences requirements. Technical support is provided to technology intensive C3I and Computational Sciences programs at the AFSC Product Divisions and other Air Force and DOD agencies. The principal technical areas are communications, intelligence and reconnaissance, surveillance, command and control, electromagnetic sciences, solid state sciences, and electronic reliability, maintainability, and compatibility.

RADC is the AF laboratory responsible for the development of a strong technology base in support of AF C3I and Computational Sciences. RADC has facilities and resources to accomplish its mission at Griffiss AFB New York and at Hanscom AFB Massachusetts. An establishment directly subordinate to the Electronic Systems Division (ESD), Hanscom AFB MA, RADC reports directly through its Commander, RADC/CC to the Commander, ESD/CC for mission accomplishment.

The major responsibilities are to plan and manage comprehensive research, exploratory development, and advanced development programs in C3I and Computational Sciences technical areas consistent with the overall technology needs of the AF and to promote the transition and application of technology in conjunction with AFSC system acquisition divisions and other using commands/agencies.

The former responsibility is accomplished through the establishment and maintenance of competent and comprehensive in-house capabilities and through contractual support. The latter is accomplished by providing technical expertise, consultation services and management support to AFSC system acquisition divisions, primarily ESD, test centers and ranges and other AF and DOD agencies as appropriate in regard to studies, analyses, development planning activities, acquisition, test, evaluation, modification, and operation of C3I systems and related equipment.

## INVESTMENT STRATEGY

The Laboratory is engaged in providing technical solutions to the Air Force needs for improved Command, Control, Communications and Intelligence. The work has traditionally been organized to conform, where possible, with the AF mission areas of Strategic Offense, Strategic Defense, C3, Recce/Intel and Technology. Within these categories there are some 60 technical areas as shown on the Technical Planning Objectives listing (Table 1). The investment strategy is developed using these 60 areas.

The resources that the Center controls (and have long term effect) are the placement of manpower; and the Exploratory Development (6.2) and to a more limited extent, Advanced Technology Development (6.3) dollars. The Center has developed an Investment Strategy for these resources.

In evolving this strategy, a process was developed to: re-examine Air Force requirements, plus other special interest areas/technologies; and through a "delphi" process with the Center Technical Investment Committee develop a "puts and takes" for manpower and 6.2 dollars. It is in this way, that the Center has developed the list of programs for emphasis and de-emphasis.

The areas of increased emphasis continue to be technology development for identifying and tracking relocatable targets; detection and tracking of low observable targets; tactical reconnaissance and intelligence architecture; photonics; reliability and maintainability; and computational sciences with particular emphasis on software availability and cost.

Project Forecast II, an AFSC effort to identify the most promising military technologies for the next twenty years, has yielded ideas that are expected to revolutionize C3I technology. The areas of increased emphasis continues to be in the areas of Battle Information Management, Integrated Photonics and SMART Skins. Project Forecast II technologies for which RADC is OPR include areas such as Photonics, Acoustic Charge Transport Devices, Knowledge-Based Systems, Survivable Communications, Smart Built-In-Test, Distributed Information Processing Software, and Smart Skins for C3I Applications. These capabilities manifest themselves in RADC OPR Project Forecast II System Concepts such as Airborne Surveillance System, Theatre Air Warfare C3I and Battle Management Processing and Display System. RADC has directed the major portion of the RADC managed FY89 budget to continue development of various Project Forecast II System Concepts and Technologies. This investment is expected to grow even larger in the future.

The RADC Photonics program initiative includes the integration of optical technology/systems for optical processing/computing, communications, photonic sensors, etc. RADC has been directed to execute the program

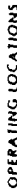
limited only by the technology. The RADC Photonics Center has been established to pursue in-house projects in optical signal processing and computing, and to provide an overall planning and coordinating mechanism for the RADC Photonics Program.

Another important Project Forecast II Program, Smart Skins, will provide the development of technology for the integration of aircraft antennas, sensors, processors, etc. into the aircraft skin, enabling higher subsystem survivability, total situation awareness, and more efficient aerodynamics. RADC emphasis in this area includes technology areas such as conformal arrays, integrated MMIC-radiating elements, distributed processing, etc. for both near term and far term demonstrations.

The general technology area of Low Observable Target Detection and tracking continues to provide substantial emphasis both for the CONUS (ADI) and European Theaters. The objective of the ADI program is to develop the enabling technologies to support detection/track identification/engagement of air breathing threats to the Continental US. These enabling technologies are required to arrive at informed Full Scale Development and P3I decisions in the early-to-mid 1990s for air defense hardware acquisition programs. RADC is the lead Air Force Laboratory in the areas of surveillance and Battle Management/C3. The technology areas being addressed by RADC with applications to both ADI and European Theaters include airborne radar, multistatics, space based radar, signal processing, target/clutter characterization, multi-media communications networks, intel-radar data fusion, decision support processing, distributed information processing, and deception and countermeasures.

A continuing important area of emphasis at RADC is the Space Defense Initiative (SDI). RADC is one of the lead AF organizations supporting SDI. RADC is involved in various technologies under the program elements of Surveillance, Acquisition, Tracking, and Kill Assessment (SATKA), Directed Energy Weapons (DEW) and Battle Management (BM/C3). Technology areas being addressed include space based large array radars, signal processing, large optics, adaptive optics, IR focal planes, monolithic microwave integrated circuits, radiation hardening, software, artificial intelligence, distributed processing, communications, computer security and IW. The SDI funds being expended in these areas will also have a definite impact in extending the state-of-the-art of technology for applications to C3I and Computational Sciences in general. RADC will continue to support this national initiative within the C3I mission areas throughout its program development.

This Investment Strategy is updated annually to insure that the RADC program is in the forefront of C3I and Computational Sciences technology which will allow battlefield commanders to manage their resources on land, in the air and in space.



OL AK Los Angeles CA · Copt Tetreault  
ESD/Def? Col Springs Co · Copt Wiedemann  
OL AB Mount Island HnW ·

\*\*\* Effective July 1988 - Col R.A. Shulstad

## RESEARCH PROGRAMS

The research program of the Rome Air Development Center is designed to provide a sound scientific basis for exploratory and advanced development programs in support of the Air Force's C3I mission. Further, the research programs are selected in order to match the Center's long range needs and to spark innovative exploratory development to provide the basis for future military systems. The majority of the RADC basic research program is sponsored by the AF Office of Scientific Research (AFOSR).

Generally, the laboratory's research requirements, reflected in the AFSC Research Planning Guide, are an outgrowth of deficiencies in the laboratory's technology base. The research program which addresses these deficiencies integrates into the total laboratory program through association with the Center's Technology TPO (TPO-4) where the research program is depicted as an integral part of the TPO-4 technology roadmaps. By this technique, the identity of research supporting technology is clearly established.

The major thrusts of the research program, directed toward supporting the C3I and Computational Sciences technology base of the Center are concentrated in electromagnetics, solid state sciences, device reliability and maintainability, artificial intelligence, thermionics and photonics. Specifically, the major thrusts of the research program follow:

Electromagnetics - Under this very broad technology base, research is progressing in the following areas: Electronic Device and Circuit Research, Wave Propagation, Radiators, Signatures and Components. The Electronic Device and Circuit Research Program explores semiconductor device phenomena, device fabrication techniques and circuit architectures with the goal of meeting future Air Force requirements for signal sensing and processing. Advances in this area are supported through the development of both new device designs and the application of new device processing techniques. This effort provides the United States a lead in silicide photodiode research. A major objective of the research in electromagnetic wave propagation is to develop and expand mathematical models to predict signal strengths of waves propagating over the surface of the earth, through the atmosphere, in the earth-ionosphere wave guide, and through the ionosphere. Efforts are focused in two specific areas: longwave propagation (ELF/VLF/LF/MF), and high frequency-ionospheric propagation (HF). Research on electromagnetic radiators emphasizes the establishment of those basic physical and engineering principles governing antenna performance in ground-based, airborne or spaceborne environments for diverse Air Force applications. The primary goal of the electromagnetic sensor research is to obtain increased fundamental knowledge of the scattering phenomena on which electromagnetic sensor systems are based so that new electromagnetic techniques can be developed to improve the sensors used in surveillance, reconnaissance, and intelligence. Electromagnetic Component Research solves fundamental

problems in millimeter-wave circuits, high temperature superconductors, and microwave/millimeter-wave magnetics to meet needs in command, control, communications and intelligence. The expansion of the frequency range of integrated circuitry to include millimeter waves will enhance the capabilities of communication and radar systems.

Solid State Sciences - Under this thrust research is accomplished in Advanced Electromagnetic Materials, Optical Circuit Components and the Physics of the Interaction of Radiation with Matter. The Advanced Electromagnetic materials work involves the synthesis, growth and characterization of electronic and optical materials in bulk, thin film and fiber form, and the identification and construction of structures that exhibit new or improved semiconductor, electro-optical and other exploitable phenomena. Primary emphasis is on militarily-distinctive, C3-oriented materials generally unavailable from the private sector. The optical circuit component research is designed to provide the basis to develop electro-optical components and establish techniques for military fiber optic communications. Optical communications systems, providing jam-proof, secure, broadband capabilities, will fulfill important roles in C3 mission requirements. Advanced communications devices providing intrusion resistant, jam-proof, and highly secure broadband capabilities will be investigated as well as sophisticated switching and signal manipulation devices. High bandwidth operational capabilities of lasers and detectors will be developed. Necessary research will be supported to establish a technology base for optical implementation of digital electronic systems in selected military applications.

The objective of work being performed under the Physics of the Interaction of Radiation with Matter is to insure the availability of fundamental information required for identifying, characterizing, and modeling radiation damage mechanisms in electronic, electro-optical and optical devices, components, and systems. This knowledge is then applied to the design of devices and the evaluation of device characteristics during and after radiation. The program provides the basis for an extensive activity in developing a hardening technology and hardened electronics for a wide variety of Air Force systems.

#### Device Reliability and Maintainability Research

Work in this area is directed at device failure mechanisms and R&M research methods. The Failure Mechanism research establishes the physics and chemistry of mechanisms of failure and the thermodynamics of degradation which affect the reliability of solid state silicon and gallium arsenide microelectronics devices. Combined microstructural, microchemical and extreme condition analyses will be performed on various thin film conductor materials to quantitatively determine the kinetics of the mechanisms of mass transport.

The Reliability Research Methods efforts develop new methods for analyzing performance limiting mechanisms in advanced device technologies. Several research studies will be conducted to establish the analytical procedures required for evaluation of semiconductor device materials and structures. Auger microanalytical studies will be continued to quantitatively evaluate these devices.

Artificial Intelligence - This effort has established a consortium of universities that are developing artificial intelligence technology applicable to C3I systems. Seven specific C3I applications have been identified which drive the technical requirements for this program. These are: Knowledge Based Mission Planner, Intelligent Analyst System, Knowledge Based Software Assistant, Expert Systems for Maintainability/Testability, Photo Interpretation, Communications Network Management, and Speech Applications. These applications are considered to be technically interrelated and the goal is for the principal investigators of the individual tasks to work jointly and cooperatively to achieve the broader objective.

Thermionics - In order to meet projected Air Force system needs for electromagnetic transmission, RADC is emphasizing the basic technology required to improve the performance of microwave and millimeter wave high power thermionic devices. Major emphasis is placed on achieving wide bandwidth, enhanced efficiency, higher powers with stable operation at millimeter wave frequencies, etc. and on techniques compatible with long life. Part of this research is conducted under the advanced thermionics research initiative with the microwave tube industry and UCLA. Other research includes development of techniques to analyze the internals of tubes on a nonperturbing basis. Both of these thrusts help maintain a strong technology base in this vital area. The results of the research are applied to specific microwave and millimeter wave tube developments.

Photonics - The processing of information using optical devices is an extremely rapid growing area with major implications and impact on a large number of fields both civilian and military where large amounts of data need to be rapidly processed.

Optical processors typically use information impressed on a light beam (often a coherent laser beam) and perform complex operations on the entire beam thereby processing all the information in parallel. The processing may be for such diverse operations as correlation for target identification and pattern recognition, image processing for feature enhancement or deblurring, weight and phase determination for the rapid control of phase array radar, etc. The information encoded on the light beam and being processed may be from a variety of sources such as actual optical imagery, radar data, acoustical data etc. This technology will fulfill many important roles in the C3 mission requirements. These include rapid phase-array radar null determination; jam proof radar to 50db; rapid target identification based on optical and radar image correlation and matched filtering; and spread spectrum acquisition based on optical 2-dimensional correlation.



Experimental devices such as spatial light modulators and phase only filters will be explored, fabricated and evaluated, and appropriate processor algorithms and architectures will be developed and studied in view of their applications to the C3 technology.

POINT OF CONTACT

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### TECHNOLOGY PROGRAM

The RADC Technology Program addressing the C3I and Computational Sciences technology needs is divided into five Technical Planning Objectives (TPOs) which are further divided into major thrust areas. The TPOs are:

TPO 1 - Command, Control, Communications

TPO 2 - Reconnaissance and Intelligence

TPO 3 - Strategic Systems

TPO 4 - Technology - C3 and Computational Sciences

TPO 5 - Special Projects

TPOs 1, 2 and 3 are applications oriented. TPO 4 encompasses nine Exploratory Development Projects. The Projects are: Surveillance, Reliability/Maintainability and Compatibility, Communications, Intelligence, Command and Control, Electromagnetics, Solid State Sciences, Photonics and Computational Sciences. These projects are aligned with the RADC Mission Directorates. The objectives and technical deficiencies being addressed are as follows:

SURVEILLANCE - Surveillance thrust develops capabilities and systems to detect, track and identify airborne and spaceborne objects. Technical deficiencies have been identified, prioritized and funded covering such areas as:

a. Passive/active sensors for detection, track and identification of airborne and space based targets.

b. Surveillance (detection and track) of low observable air launch cruise missiles in background clutter and ECM.

c. Airborne surveillance of low observable targets in both strategic and tactical environment.

d. Survivable, mobile and jam resistant tactical radar.

e. Detection and tracking of air launched, low observable targets.

f. Fault tolerant signal processor to meet clutter and ECM environment sensor requirements.

g. Affordable, high signal fidelity transmit/receive modules with ultra wideband and high performance and reliability.

COMMUNICATIONS - Communications thrust advances the state-of-the-art in voice and data communication developing secure, survivable and

jam-resistant communications. Technical deficiencies have been identified, prioritized and funded covering such areas as:

- a. Increased data capacity and reduced vulnerability of long haul communication networks.
- b. Increase receive-transmit bandwidth/power to reduce vulnerability of satellite communications.
- c. Reliable beyond-line-of-site strategic communication system.
- d. Optical communications network is required for conducting and radiating lightwave transmissions, invulnerable to Electromagnetic Interference (EMI) and of very high capacity.
- e. Mobile tactical jam resistant capability for advanced survivable communications.
- f. High capacity covert distribution intelligence communications network.
- g. Low cost, miniaturized and highly efficient communication signal processing capability.

INTELLIGENCE - Intelligence and Reconnaissance thrust develops automated equipment and techniques to gather, translate and condense massive amounts of intelligence data. Technical deficiencies have been identified, prioritized and funded covering such areas as:

- a. Real time correlation and fusion of large volumes (10,000 reports per hour) of multi-sensor data.
- b. Imagery exploitation of extremely high volume (terra-bytes) of digital multi-sensor, multi-spectral image data which must be rapidly processed, stored and displayed.
- c. Transform digital cartographic data into realistic views of the earth's surface for combat mission familiarization/rehearsal and C2 environments.
  - (1) Improved analytical process to reduce the amount of time to issue warning.
  - (2) Improved database update process so that databases are current for decision makers.
  - (3) Small, cost effective devices for the timely collection, recording storage and dissemination of intelligence data from advanced sensors.

(4) Voice data entry and continuous speech processing to improve COMINT analysis and the man-machine interface for cockpit and workstation environments.

(5) Alternate sources of technical intelligence to enhance space object identification threat system estimates and SIGINT analysis.

RELIABILITY AND COMPATIBILITY - Reliability and Compatibility thrust is the lead for military service electronic reliability and maintainability standardization. Technical deficiencies have been identified, prioritized and funded covering such areas as:

a. Measuring and predicting complex microcircuit performance and quality assurance procedures for MMICs.

b. Emphasis on designing for reliability to reduce excessive amount of unnecessary C3 system maintenance and down time.

c. Measurement techniques for HPM effects on C3 and weapon delivery systems.

d. Measurement and procedures for the functional assessment of MMIC to undesired EMI.

e. Techniques to determine the operating characteristics of hybrid photonics devices to high level RF energy.

ELECTROMAGNETICS - Electromagnetics thrust is directed at research in three major areas: antenna and associated electromagnetic components; propagation of RF energy; and scattering of electromagnetic energy from targets and terrain. Technical deficiencies have been identified, prioritized and funded covering such areas as:

a. Reduction of array size and weight, employing cost effective solid state devices with increased system bandwidth, and relatively low sidelobe performance.

b. Less costly beam steering components for ATSR, SBR AASR.

c. Size, weight and cost limitations, of MILSTAR synthesizers.

d. Development of superconductivity components for lower noise, higher speed and bandwidth.

e. Knowledge of bistatic scattering statistics for signal processing for multistatic surveillance systems.

f. Techniques to detect reduced radar cross section airborne targets utilizing monostatic radars.

g. Statistical models to predict and exploit auroral zone behavior.

SOLID STATE SCIENCES - The Solid State Sciences thrust is directed at research in: electron device technology; electro-optics; photonics; electromagnetic materials; and radiation hardening. Technical deficiencies have been identified, prioritized, and funded covering such areas as:

- a. Development of high resolution/low cost IR array imagery processing devices and simplified IR image processing.
- b. Control of Phase Array Antennas employing Photonics Devices.
- c. Development of intrusion resistant fiber optic communication link and photorefractive and non-linear materials for optical processing.
- d. Bulk/Ultrastructured materials for fiber optic and millimeter wave devices.
- e. Superconducting devices
- f. Radiation Hardened space qualified processing.
- g. Radiation resistant MMIC circuit.

COMMAND AND CONTROL - Command and Control thrust utilizes technologies such as Artificial Intelligence, distributed data bases, software and decision aids to develop systems that automate and streamline the command and control process. Technical deficiencies have been identified, prioritized, and funded covering such areas as:

- a. Application of Artificial Intelligence to tactical Battle Management to reduce manpower need, improve interoperability and survivability and be responsive to upgrade and improvement.
- b. Incorporate Decision Aids within Battle Management system, to decrease manpower and training requirement through automation.
- c. Greater user/development interface in acquisition of Decision Aids by Implementing Command and Control technology laboratory.
- d. Survivable responsive, adaptive SIOP planning in trans attack environment.

PHOTONICS - Photonics thrust is directed at research toward integrated optic systems, devices and processes for future optically based AF systems. These systems will be invulnerable to electromagnetic interference (EMI), electromagnetic pulse (EMP), and radio frequency interference (RFI). They have high capacity, are potentially small in size and highly reliable and will require low power. Technical deficiencies have been identified, prioritized, and funded covering such areas as:

a. Broad based optical computing including processing of algorithms, artificial intelligence and optical interconnects.

b. Optical surveillance addressing requirements for counter stealth, precision tracking, target ID and discrimination. It includes both active and passive sensors.

c. Laser communications including transmitters, receivers, multi-beam arrays and processors.

d. Digital optical computer architectures, components and algorithms.

e. Optical signal processing for ELINT exploitation.

f. Optical mass memories to include both disk and tape formats, erasable and non-erasable media for mass storage in a tactical environment.

g. Optical Beam Forming Communications/Surveillance antenna processors to include digital beam forming signal distribution, matrix vector processing and antenna nulling.

h. Infrared Sensors in support of space surveillance and image transmission and processing.

COMPUTATIONAL SCIENCES - Computational Sciences thrust addresses solutions to the Air Force needs in software engineering technology, systems technology/distributed systems and artificial intelligence/knowledge-based systems. Technological deficiencies have been identified by operational commands (TAC, SAC, Space Command, etc.) development and support commands (AFSC, AFLC, MAC, AFCC, etc.) and Air Force and DOD studies. Work has been prioritized and funded covering such areas as:

a. High cost and poor reliability of mission critical and embedded software.

b. EMP susceptibility of computational systems.

c. Inadequate hardware and software tools and techniques for exploiting distributed and high speed parallel computers in computationally bound military applications.

d. Ability of present Artificial Intelligence (AI) technology to scale up to large and/or real-time weapons systems applications.

The RADC technology program is conducted both in-house as well as at various contractor and academia facilities. The following describes the work within each of the TPO areas.

RADC TECHNOLOGY OBJECTIVES - A description of each of the TPOs follows.

TPO-1, TITLE: COMMAND, CONTROL AND COMMUNICATIONS (C3)

This Technology Planning Objective (TPO) addresses work RADC is pursuing toward improvements in the Air Force's capabilities to perform its command, control and communication (C3) mission.

Within this TPO there are four major areas of concern; namely, Common C3, Strategic C3, Tactical C3 and Electronic Combat. The overall goals of TPO-1 are to:

- a. Increase survivability and endurance of Long-Haul Common User Communication.
- b. Develop an Anti-Jam Survivable means for disseminating Emergency Action Messengers (EAM).
- c. Provide secure Jam Resistant communications, surveillance and force management systems within TACS.
- d. Detect, locate and classify enemy C2 force elements.

COMMON C3 is defined to include those areas that are not specifically tactical or strategic in nature but provides technologies that will improve survivability, connectivity and security of the long haul common user communications. Although much of this work is in direct support of the Defense Communication System (DCS), the technologies developed are frequently applicable to the tactical and strategic missions.

In the switching and control of a node, the application of advanced routing architectures and multi-net gateways are being pursued to enhance the connectivity and interoperability of communication systems. The use of endurable communication links is vital to the DCS along with improving link availability through the application of adaptive antennas, signal processing and spread spectrum modulation technologies. In addition to link survivability, the network must be capable of withstanding both physical and electronic assault. Improvements in both hardware and software for the control of a complete and secure network are needed. Such issues as fault isolation, distributed technical control, rapid communication net restoral/reconfiguration and the detection and identification of Electronic Counter Measures (ECM) are being addressed.

Space communications is a much used and critical portion of the support communications mission, but it currently suffers from the lack of anti-jam capability, mobility, flexibility and availability. These deficiencies are being addressed by providing the capabilities to operate in the SHF/EHF bands with new conformal beam forming antennas, RF

generators, robust signal formats and reducing the potential for self interference at these critical frequencies. Both ground and airborne applications are being considered.

Communication security is an activity that is mandated by national policy. Programs in TEMPEST automation, VHSI/VLSI vocoders and voice intelligibility will add to the Air Force capabilities to meet this mandate.

The STRATEGIC C3 goals are to develop the technologies which will lead to a survivable and enduring C2 structure capable of positive control of the strategic forces on a global basis even in the hostile environment of physical and electronic attack, disturbed propagation and enemy SIGINT activities. The endurance of the command authority throughout a full spectrum conflict will also require the graceful adoption of new technology, along with new procedures. The resulting improvement in Strategic C3 is both mandated by the evolving threat and advances in strategic weaponry.

The development of Signal Processing to support beam and null steering and rapid retune capabilities, along with a variety of signal processing techniques for both narrow and wide bandwidths, are the keystones to future systems. The VLF antenna for ground and air locations remains a major technological issue, as does the need for low probability exploitation transmissions across the band. Those technologies which permit communications to be adaptive, wideband, and mobile will afford low probability exploitation transmissions across the band.

The Strategic C3 experiment is to investigate the technological issues surrounding this endurance issue considering the use and loss of distributed/data bases and the communications interconnecting the data bases. Understanding reconfiguration and reconstitution of the assets to provide command continuity is critical to the system architecture and doctrine.

TACTICAL C3 contains all of the elements of Command, Control, Communications and Intelligence. The major technical deficiencies within today's tactical C3I systems are survivability, capability, timeliness and mobility. It is these system characteristics that are being addressed in the RADC program for Tactical C3. The four functional areas of communications, surveillance, command and control and intelligence will be discussed in order.

TACTICAL COMMUNICATIONS: The approach to meeting the goals of the tactical communications mission is to solve some of the near term problems such as transistioning fiber optic cables into the field at the earliest possible time while taking a longer term look at systems vulnerabilities to determine future needs. In the near term, standards for fiber optic connectors, sources and detectors must be prepared. In the future there is a need for a family of transceivers, optical multiplexing, RF transmission, transmission over single mode fiber and intrusion resistance cables. The goal of advanced survivable



communication technology is to develop an enduring communications base that will enable the future TACS to survive the hostile ECM threat. Consideration will not only be given to the growing jammer threat, but also to the need to reduce vulnerability to intercept.

For the longer term solutions, the Communications Vulnerability Assessment (CVA) effort with the associated evaluation of network facilities will provide electronically hardened communications system developments. From this, the design and development of robust distributed and adaptive networks can be effectively done. Within this overall framework is the need for specific advancements in survivable multi-media channels. Low cost data links and associated phased array antennas are key technical issues for near real time information flow and weapon control while being subjected to intensive jamming and SIGINT activity. Voice communications is an important part of the tactical mission, but it must be secure and jam proof. Digital techniques in the EHF band are being exploited to develop a low probability of intercept and highly jam resistant voice channel for air to air use.

SURVEILLANCE: The number, speed and turning capability of airbreathing vehicles within a theater continues to grow while the potential for radar cross section reductions become more real. These target characteristics along with an ever expanding and sophisticated EW threat plus an increasing threat from a variety of weapons designed to destroy ground and airborne surveillance/C3 assets presents a very challenging task for the surveillance and ID systems. Since no single surveillance platform or sensor type can deal with this threat, the Surveillance program includes the development and demonstration of the technology for: a highly mobile advanced ground based phased array radar; a multi-mode ground based passive surveillance system; an advanced airborne conformal phased array system with both active and passive modes; and the netted surveillance technology required to integrate the outputs of these new sensors to generate a single unambiguous air situation picture.

The goal of the Advanced Airborne Surveillance Radar (AASR) is the development of an airborne sensor technology base for an advanced multispectral sensor as well as evolutionary improvements to AACS for low observable threats in a complex EW environment. The emphasis relates to airborne surveillance in both strategic and tactical environments. Key objectives are the restoration of surveillance in jammed sectors, improved tracking of multiple and maneuvering targets, extended detection to stealth targets, high mach missiles and helicopters as well as reduce vulnerability to physical attack and provide for positive identification. The major technical thrusts are to demonstrate airborne conformal array technology, integrate active and passive sensor data, and demonstrate multi-band/spectral airborne sensor technology.

The goal of the Advanced Tactical Surveillance Radar (ATSR) program will be to develop and demonstrate key technologies associated with survivable, mobile and jam resistant tactical radars. Goals include the capability to detect, locate, track and identify airborne targets in a

multi-threat hostile environment including low RCS to provide rapid deployment capability for physical survivability; and to support the demonstration of non-cooperative ID. Efforts to develop the microwave radar technology necessary for the development of C/S band microwave radars in the post-1990 time frame which meet the tactical threat include Low Cost Phase Shifters, the High Stability TAC Transmitter and Demonstration of Automatic Adaptive Radar Control.

COMMAND AND CONTROL: The current methods of doing force management is largely a manual process and is far too slow for the dynamics of modern tactical warfare. The near term introduction of automated aids and the longer term systems design comprise the RADC program. The three main technical areas being pursued are modeling and simulation, functional automation and man-machine interface. Key features of this approach are that it is evolutionary, relies heavily on user participation and will possess the qualities of interoperability with the current and other evolving force management equipments and concepts. This program will lead to a capability to perform Command & Control functions in a modular and distributed manner. The solution to distributed and interacting data bases is vital to implement the future survivable command and control concepts derived in the Air Force 21st century Tactical C2 study.

A communication structure of fiber optic and coax cables that form the backbone of the Command and Control Technology Laboratory (C2TL) has been installed at RADC. This will create the environment for testing/evaluating many of the concepts of heterogenous distributed systems that one would expect to find in the real world. These tools and concepts provide powerful new approaches to tactical warfare management.

A program for the development of a Ground Attack Control Center (GACC) will provide those technologies and strategies to bring together the total system control of sensors, data processors, weapon selection and control for the air interdiction mission. Both of these programs are being conducted in close coordination with the ESD acquisition directorates.

INTELLIGENCE: Intelligence covers development of Sigint exploitation technologies and techniques and Combat Sensor. Management and Correlation. Command, Control, Communications and Counter Measures (C3CM) Deception is also covered under the Intelligence Mission. In modern tactical warfare, intelligence must be an integral part of the command and control structure and automated to the point that it is compatible with that structure. The approach being pursued is one of both near term and long term developments which will result in a highly automated multi-sensor system capable of meeting the force management needs in a highly dynamic air and ground war.

In the sensor area, work is ongoing to develop a multi spectrum capability. An effort in the automation of SIGINT exploitation and reporting will significantly contribute to the intelligence data process. The Advanced Imagery Exploitation System (AIE) will provide a near real

time capability for detection, identification and precise location of high priority tactical targets. Technical areas applicable to Sigint includes automatic signal detection, automatic signal recognition and near real time information extraction.

The Penetration Analysis Support System along with programs like Sensor-Fusion Analysis will aid in the process of penetration analysis and decision through automating the mostly manual process. Within the tactical theater there are many diverse sensors and support subsystems that have a wealth of capability and information. They must be brought together in a cohesive and organized manner to produce the most effective results. The Combat Sensor Management and Correlation program is intended to do this and make available to the force manager the best possible picture of the battlefield.

As cited above, the current methods of doing force management is largely manual and is far too slow and simplistic for the dynamics of modern tactical air and ground warfare. The near term introduction of automated aids and the longer term total systems design comprise the RADC program.

The three main technical areas being pursued are modeling and simulation, functional automation and the man-machine interface. Key features of this approach are that it is evolutionary, relies heavily on user participation and must possess the qualities of interoperability with the current and other evolving force management equipments and concepts. This program will lead to a capability to perform Command & Control functions in a modular and distributed manner. The solution to distributed and interacting data bases is vital to tactical and strategic activities if they are to survive in projected scenarios.

Electronic Combat encompasses Command, Control Communications Countermeasures (C3CM), Electronic Warfare (EW), and Suppression of Enemy Air Defenses (SEAD). This area addresses C3CM as defined by DOD Direction 4600.4 as the integrated use of OPS, deception, jamming and destruction, supported by intelligence in order to deny information to, influence, degrade or destroy adversary C3 capabilities. The countermeasure strategy addressed in the C3CM concept has as its objective the countering of the enemy command and control (C2) function, with the countering of the communication (C) function only as a means to the end.

As defined by JCS MOP 185, the goal of the C3CM is to deny enemy commanders effective command and control of their own forces while maintaining effective command and control of friendly forces. The RADC Electronic Combat work supports the ESD C3CM program designed to develop and field capabilities so that the TAF can employ C3CM warfare strategy effectively. The specific objectives are to: develop a target recognition capability for C3CM battle information management and execution; develop and evaluate decision aids for use in the existing C3 structure to support C3CM and control friendly emitters; develop deception techniques; and to provide an integrated C3CM capability for tactical use.

Integration of intelligence and C3C4 will: improve real-time intelligence support to C3C4, provide rapid assessment of enemy intentions, provide intelligence target/EC/deception options to the 21st century TAC's battle staff in near real-time, provide fused, correlated, analyzed and assessed intelligence information regarding enemy courses of action and suggested friendly responsive courses of action, and develop techniques and tools for imitative, manipulative, and operational deception of enemy C3.

These developments will provide the Air Force with the technologies required for force enhancement through an integrated C3 system which orchestrates the use of lethal and non-lethal weapons in a timely manner for Electronic Combat (EC).

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TPO-2, TITLE: RECCE/INTEL

This Technology Planning Objective (TPO) is directed at Advanced Engineering Development and Acquisition in the areas of: Surveillance and Correlation/Fusion, Wideband Recording, Speech Processing, Knowledge Based Intelligence Systems, and C3I Data Base Techniques. Exploratory Development work addressing these areas is under the RECCE/INTEL portion of the Technology TPO, TPO-4. Exploratory and Advanced Development investigations in the areas of Signal Intelligence, Combat Sensor Management and Correlation, and Intelligence C3 Countermeasures (C3CM) Integration are being accomplished under the C3 TPO, TPO-1.

CORRELATION/FUSION brings together all RADC efforts that have as an end objective the processing and integration of various types of data into finished intelligence. Correlation/Fusion encompasses the aforementioned technical areas of Data Handling, Imagery Exploitation, Precision Guidance and Strike products.

DATA HANDLING addresses three areas namely, Analysis and Correlation, DOD Indications and Warning, and Intelligence Data Handling Systems. The objective is to provide engineering, technical, and acquisition expertise to develop, modify and improve software and hardware for processing scientific and technical data. Technical areas include automated text processing, sensor correlation/fusion, relational and distributed data bases, analysis techniques for remote sensing data, and SIGINT correlation. The work can be described as follows:

ANALYSIS AND CORRELATION is directed at augmenting conventional S&T intelligence, long range launch detection, and vehicle identification. The technologies are directed at analysis and exploitation of RF signals and unintentional electromagnetic emissions, including emissions from rocket engine exhaust plumes.

DOD INDICATIONS AND WARNING (I&W) efforts are concerned with improving and modernizing our ability to monitor, assess, and exploit I&W information. Work in this area includes exploring new technologies and their applicability to the I&W arena. Expert system technology has been applied in the space foreign launch, long range air, and strategic relocatable target areas. These systems demonstrate the usefulness of the expert system technology and advanced-man-machine interfaces to assist the I&W analyst in performing his mission. These diverse and complex domains were chosen to get the greatest payoff in terms of usefulness to the operational I&W segment, and to stress the limits of the technology. Areas now being investigated are knowledge base structures, natural language processing, and operational transition problems.

INTELLIGENCE DATA HANDLING SYSTEMS (IDHS) provides the means for the

systematic replacement of technically obsolete computers, peripheral equipment, and storage and retrieval equipment in the Air Force, Unified and Specified Commands, and the Defense Intelligence Agency (DIA). Major technical issues are those that: correct deficiencies and weaknesses in the current methods employed as aids in the analysis of intelligence data; develop concepts which have the potential for automating and improving upon current analysis methods; develop and implement software and hardware capabilities within user organizations to provide more efficient, complete and timely intelligence data.

IMAGERY EXPLOITATION will fully exploit the intelligence and information content of multi-sensor and multi-spectral reconnaissance imagery in support of the Tactical and Strategic Forces, Space Forces, and other DOD organizations. The research and development thrusts include such system/technology areas as: photo interpretation and image analysis, understanding and defeating the denial and deception tactics that can be applied to counter image systems, digital image processing and manipulation (for the purpose of; image analysis, image compression, image enhancement), target and feature recognition (with the goal of full automation), three dimensional target modeling, and the specification of and utilization of specialized data bases for (manual, semi-automated and automated) image interpretation and analysis. This area also addresses the integration of these areas to allow for; the rapid derivation of combat intelligence, tracking of mobile targets (or targets with suppressed signatures) and to provide timely and accurate, target intelligence and target intelligence materials for current and future weapon systems.

PRECISION GUIDANCE and STRIKE PRODUCTS will develop an automated capability to process, store, maintain and format Earth surface data in support of Air Force wide requirements for planning, navigation/guidance and targeting. Major technical issues addressed include: consolidation of Air Force wide requirements for digital cartographic product specification(s); the implementation of generic, reusable and transportable digital application processes along with the required underlying Earth surface data base(s); and the development of advanced terminal homing reference scene generation capabilities.

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### TPO-3, TITLE: STRATEGIC SYSTEMS

This Technology Planning Objective (TPO) is directed at providing viable surveillance and warning sensors coupled with command and control functions for surveillance systems in support of Atmospheric Surveillance, Space Surveillance, Strategic Defense Initiative (SDI) and the Atmospheric Defense Initiative (ADI). The challenges of placing radar and large optical systems in space, the detection and tracking of low observables, and the operation of sensors for tracking objects in space for strategic detection are of primary concern.

**ATMOSPHERIC SURVEILLANCE & WARNING:** The atmospheric surveillance and warning thrust considers both atmospheric and space surveillance and include technology areas of space based radar, low observable surveillance and intel/special radars. These thrusts are driven by a common understanding of the threat environment and are developed by an integration of technology (TPO-4) initiatives i.e. (signal processing, sensor fusion, solid state device technology, antennas, propagation etc). The approach being taken is to tune the sensors to the threat observables implying an adaptive multispectral design.

**SPACE BASED RADAR (SBR)** - The goal of SBR is to develop a sensor technology base to address the surveillance of all targets including very low observables in a hostile jamming environment. The emphasis is on detection and tracking of Air Launched Cruise Missiles in all background clutter and ECM environments. Technology thrusts include wideband multispectral, frequency scan and distributed aperture systems which have the potential of providing lower costs and survivability. Two parallel efforts have been initiated which will each develop 100 L-band SBR transmit/receive modules. The modules will be designed with space qualification in mind. A wideband (890-1400 MHz) SBR design will be developed. The objective is to determine how a large deployed aperture can be achieved for a corporate-fed array with wideband capability and packaged to fit one half the shuttle bay space. A version of an SBR will be ground tested to enhance the probability of success of the first space launch. Also an active space test of a subscale array via a space shuttle attached experiment is planned. Innovative SBR concepts have been solicited on a PRDA. The objective is to develop new second generation SBR concepts which provide attractive alternatives and offer dramatic improvements in survivability and cost. The focus of this research is in SBR system architecture, concepts of operation, component technology, packaging and deployment.

**LOW OBSERVABLE SURVEILLANCE** - The goal of the Low Observable sub-thrust includes the evaluation and development of the threat observables, sensor background and responsive technology for the detection and tracking of airbreathing, low observable targets. The foundation of the thrust is multi-spectral target and background characterization. This was accomplished through an interactive modeling and validation measurement program. The development of bistatic sensors to achieve low observable surveillance is a major technology initiative.

Further, the development and demonstration of fusion processing to integrate and enhance sensor performance is considered important to achieving the requirements of wide area coverage for low observable surveillance.

INTEL/SPECIAL RADARS - Unique sensors for the surveillance of satellites, missiles and aircraft have been and continue to be developed and improved to meet requirements for space track, attack warning, intelligence and air defense. There are no 6.2 funds expended in this Intel/Special Radars subthrust since all of the work performed is in support of external agencies who reimburse RADC for the technical effort expended to effect technology transfer mainly to the CONUS OTH-B Program.

SPACE SURVEILLANCE AND WARNING provides methods to conduct Mission Payload Assessment (MPR) of space objects, and tracking, targeting and kill assessment for ASAT and attack warning by electro-optical concepts. High frequency ducted ionospheric concepts are investigated to provide advanced HF communications and surveillance techniques.

ELECTRO-OPTICAL SURVEILLANCE - The goal of this subthrust area is to develop and demonstrate advanced electro-optical surveillance systems for the detection, track and identification of airborne and space-based targets. The program includes evaluation and trade-off of active and passive sensors and sensor systems, as well as simulation of their performance under a variety of backgrounds across a range of target parameters with particular emphasis on the low observable threat. In addition to sensor and hardware issues associated with this area, the program includes a thrust phenomenology to assess the completeness of the present infrared databases for particular background and clutter environments. In parallel with that assessment specific measurements of selected targets are scheduled against a variety of candidate backgrounds to validate and supplement the existing database. Specialized processing techniques will be developed to derive maximum system performance in severe optical "clutter". Additional processing will be employed to examine the potential beneficial effects on system performance of optical system when used in a multi-wavelength mode or, when employed with sensors in other bands entirely. Non-imaging techniques to perform mission payload analysis and space object identification functions for deep space objects will be investigated. The focus of this program will be to implement cost effective measures, such as photometry and speckle techniques, both of which require small cheap telescopes. Technology developments include simulation and modeling, and multispectral data analysis, advanced optics design and fabrication techniques, and sensor demonstrations.

DUCTED IONOSPHERIC PROPAGATION - The Ducted Ionospheric Propagation subthrust is aimed at increased understanding of ducted modes and their usefulness in surveillance and communications application. Recent theoretical research has indicated the possibility of achieving reliable long-range (10,000 km) HF (3-99 MHz) radiowave propagation by exploiting ducted modes in the ionosphere at altitudes in the 150-250 km range. Natural, as well as artificial modification of the ionosphere by means of



intense radio frequency heating near the duct injection point, have been investigated as a promising means of achieving coupling. A satellite experiment is planned to place a unique wideband HF (6-30 MHz) receiver system at altitudes within the expected ducting regions. Several ground transmitters will be used to inject radio signals into the ionospheric ducts utilizing both natural and man-made ionospheric irregularities. These ducted transmissions will be received at the satellite at distances greater than 10,000 km. Several signal parameters will be measured to establish the characteristics of the ducted modes. The satellite receiver system is completed and has successfully passed the required environmental tests and is now fully space qualified.

#### STRATEGIC DEFENSE INITIATIVE (SDI)

RADC manages seven Strategic Defense Initiative (SDI) Work Package Directives (WPDs) and provides technical support to four additional WPDs managed by other organizations. During FY89 we expect to spend over 70 manyears of RADC manpower supporting the SDI. The following paragraphs briefly address the WPDs that RADC is managing.

**Large Radar Array Technology** - The objective of this WPD is to develop the key technologies necessary to implement large survivable space-based discrimination radars. The program address the discrimination of re-entry vehicles from decoys during the post-boost phase of ballistic-missile trajectories. The technologies include transmit/receive module development and the fabrication/deployment of large phased arrays.

**Real Time Signal Processor** - The objective of this WPD is the development of spaceborne processors and their associated software that can meet the numerical rate and physical design requirements of SDI space elements at the sensor level, operate autonomously for long periods of time, be fault tolerant and be capable of system reconfiguration and reprogramming.

**SATKA LARGE OPTICS TECHNOLOGY** - The objective of this WPD is to develop technologies for producing, fabricating, maintaining, testing and evaluating large optics for all SDI space surveillance systems. These optics must: 1) operate at liquid He temperatures; 2) be produced at rapid rates; 3) survive the nuclear prompt environment; 4) maintain very low scatter surfaces, and 5) support the SDI mission over extended periods of time.

**DEW LARGE OPTICS** - The objective of this WPD is to develop the advanced large optics technologies required by large primary mirror optics for use in space-based and ground-based laser weapon systems. This task has direct responsibility for technology development for the large optics for GBL ground segment, GEL space segment relay and fighting mirrors, SBL and Lamp.

**Atmospheric Compensation** - The objective of this WPD is to develop the low power adaptive optics technology required for ground based laser weapon systems. The major technology elements include wavefront

correctors, wavefront sensors, wavefront reconstructors and spatial light modulators.

Advanced Tracking, Pointing (ATP) and Fire Control - The objective of this WPD is to provide a complete and integrated solution to attack management and to demonstrate the feasibility of achieving the mission timelines for Directed Energy Weapons Systems. The major technology elements include fire control and ATP interface, attack management testbed, decision algorithms and fire control advanced concepts.

BATTLE MANAGEMENT C3 TECHNOLOGY - The objective of this WPD is to design and develop the tools and techniques necessary to implement policy for secure processors and distributed processing systems, to produce policy responsive BM/C3 algorithms, protocols and decision aids, to design, develop, test and evaluate technology for space-based elements of strategic defense battle management communications network and to quantify risk and cost. The major technology elements include high performance, fault tolerant, radiation-hardened secure Bm/C3 processing devices, systems and utility software protocols, algorithms and decision aids responsive to system employment policy and communications devices and networks to support SDI system.

In addition to the WPDs that RADC manages that are addressed above, RADC provides technical and contractual support to Space Division on the SATKA Integrated Experiment WPD, to AFSTC on Infrared Focal Plane WPD, to the US Army on the Radiation Hardening WPD, and to AFOSR on the Tera Hertz Sensor Technology portion of the Innovative Science and Technology WPD.

#### ATMOSPHERIC DEFENSE INITIATIVE (ADI)

The Atmospheric Defense Initiative addresses the "atmospheric threat" created by the introduction of low observable (Cruise Missile and Stealth) technology and compliments the layered defense strategy started under the Space Defense Initiative.

The system concept emphasizes an evolutionary process that first addresses near-term improvements to the present surveillance systems while initiating programs to develop technologies required to support long-term objectives. New sensors, as well as added uses of fused data, are driving the Surveillance and Command and Control functions.

#### SURVEILLANCE

The Surveillance function is addressing the Low Observable threat. The program is directed at the evaluation and development of the threat observables, sensor background and responsive technology for the detection and tracking of airbreathing, low observable targets. The foundation of the thrust is multi-spectral target and background characterization. This was accomplished through an interactive modeling and validation measurement program. The development of bistatic sensors to achieve low observable surveillance is a major technology initiative. Further, the development and demonstration of fusion processing to

integrate and enhance sensor performance is considered important to achieving the requirements of wide area coverage for low observable surveillance.

BATTLE MANAGEMENT/C3 - This area includes C2, communications, and intelligence. Specific research areas include, but are not limited to, functional augmentation of the present C2 system to meet ADI defense capabilities, survivable multi-media communications, decision support software (i.e. expert/knowledge-based systems, artificial intelligence) and intelligence concepts/systems. The C2 component integrates the surveillance component and provides direction to the engagement component.

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#### TPO-4, TITLE: TECHNOLOGY

This Technology Planning Objective (TPO) is the technology foundation for future solutions to problems within the Air Force C3I mission. Though the "ilities" may have direct system application, they are reported in this TPO because of the breadth of their usage. There is concerted effort on the part of management to insure that there is continual cross fertilization between the thrusts in TPO-4 and the other TPOs. As technologies in TPO-4 mature, they are transitioned into the application oriented TPOs.

TPO-4 is comprised of two Technology Areas - C3 and Computational Sciences. There are eight thrusts within the the C3 Technology Area, representative of the technical fields of the Center mission directorates. There are three thrusts within the Computational Sciences Technology Area. The majority of the work identified in this TPO is Exploratory Development directed at performing studies, experiments and demonstrations to further the body of technical knowledge.

SURVEILLANCE - thrust contains two basic technology subthrusts; Signal Processing and Signal Generation and Control. These technology subthrusts form the foundation for future capabilities.

SIGNAL PROCESSING - Signal Processing has the primary objective of providing the highest probability of detection in a time varying environment containing natural and man made interference while simultaneously minimizing false alarms. Signal processing techniques are made adaptive so that they are self optimizing in this type environment. With the recent advances in device technology and real time processing algorithms, the signal processing program is oriented heavily toward actual reduction to practice and experimental evaluation in an actual RF environment. Polarization Algorithm/Experiments will provide an extensive evaluation of several potential discrimination algorithms and will also provide much needed experimental data on the polarization signature on a variety of target types as well as ground clutter, weather clutter and chaff. The optimum modulation/filter will be determined from an assessment of polarimetric processing for the optimum transmit/receive response for target detection and estimation over a two channel radar system.

Performance Limitation Studies have been initiated to update the diagnostic tools to determine the figure of merit for advanced radar systems as affected by the errors and limitations of a system's operating parameters. A wide range of system factors such as synchronization, time and frequency instability, A/D conversion, dynamic range and netting are some of the more immediate issues.

The recent developments in distributed processing, device technology (VHSIC) and high order languages have been used in the design of the Signal Processor for E3A/AASR to achieve high throughput, increased reliability, reduced maintenance and life cycle costs. The Signal

Processing Program will evaluate and utilize the very latest device and algorithm technology (i.e., VHSIC, AI, etc) to develop and demonstrate new fault tolerant signal processors to meet complex clutter and ECM environment sensor requirements. Emphasis is placed on the detection of low observable targets in several natural and man-made electromagnetic environments. Processing architecture technologies are being developed to integrate systolic processors and general purpose signal processors with solid state transmit/receive modules to meet the requirements of future multispectral sensors. Knowledge based processing which integrates signal and tracking processing into a powerful adaptive multi domain processing sensor is the major pressing thrust. This algorithm will be demonstrated using field collected data from experimental and operational surveillance sensors.

**SIGNAL GENERATION AND CONTROL** - The Signal Generation and Control subthrust is aimed at developing and demonstrating affordable, high signal fidelity transmit/receive modules for ground, airborne and space surveillance systems. Emphasis is on small size and light weight for wide band, high dynamic range analog and digital signal interfaces. A second major initiative is the development of high efficient millimeter wave T/Rs to support space communication as well as advance low temperature cathodes to improve T/R life. Air Force surveillance systems require increased capability to detect and track very small targets in clutter. Airborne and space systems have an additional requirement for small size and weight and increased efficiency to meet platform configurations. Emphasis is on the development of dual multi band module technology which will result in increased detection and tracking capability for small targets in high clutter environments.

Adaptive Solid State T/R Module Circuit Technology is being developed including improved concepts, control techniques and validation test procedures to meet ground and airborne surveillance systems. Emphasis is on the development and demonstration of circuit techniques in MCM form that result in high performance low cost T/R modules, low cost chip/module integration, and automated testing techniques with applications to SBR, AASR and ADI.

Research is conducted on high current density cathodes where the objective is to develop a scientific base for cathode design. Results to date include identification of a strong metal-metal bond structure and the achievement of low temperature emissions.

**COMMUNICATIONS** - The Communications thrust supporting C3I is a combination of generic technology development and applied telecommunications networks required for effective military Command, Control and Intelligence systems. These developments are concerned only with the information transport aspects of C3I systems wherein the information must be transmitted safely through environments ranging from local airbases through regional, theater or worldwide areas subject to hostile attack from natural causes, enemy actions or both. This program is carefully structured to apply the emerging electronic and photonic processing technologies to specific problem areas in Air Force C3I

systems which cannot survive without accurate, timely and protected information continuously transported between its constituent nodes in sufficient quantity. The subthrusters Adaptive Signal Processing and Networking Technology will be discussed below.

COMMUNICATIONS SIGNAL PROCESSING -- An aggressive, broad-based technology program provides the supporting base for the specific enduring communications subthrusters. The communications needed to enable implementation of the advanced C3I systems planned for the mid-to-late 90s demand advanced technology efforts in signal processing. The self-adaptive communications terminals necessary to protect the radio communications links from enemy interference in the late 90s networks must evolve from the Low Probability of Exploitation (LPE) technology efforts and be implemented with the Acoustic Charge Transport (ACT) technology now in early development. Similar network processing efforts must be developed at the same time to insure that the communication links can be effectively utilized to form enduring networks that support the advanced distributed C2 nodes that make up the C3I systems. This requires continued progress in our current network studies that will lead to the design of effective knowledge-based management and control systems by the late 90s. An important part of the technology advancements needed to meet these goals will be furnished by the Photonic applications now in early development. These processor efforts in phased arrays, null steering and network processors will be necessary to implement the very high capacity systems required later on.

STRATEGIC COMMUNICATIONS NETWORKS - The goal is to improve the capacity of communications and enhance survivability during the most critical periods of the battle management, i.e., trans- and post-attack. the technological improvements sought provide alternative survivability attributes that make it a key area of interest for communications beyond line of sight. While this subthruster principally addresses strategic communications, there are applications to the tactical theater as well. Completion of the most advanced modem developed to date will be demonstrated. This modem, which performs either at high capacity or in the AJ mode, has been built to be pin for pin compatible with the future HF standard radio (ARC-190). Plans are to begin a test for compatibility between this modem and the Government-acquired Automatic Channel Processor, which provides both the automate link quality analysis function necessary to improve circuit reliability of the HIF radio and also provide an AJ hopping capability for the radio. Tests will be conducted. ground-to-ground and ground-to-air using MAC aircraft of opportunity. Additional capability will be added so that demonstration will show the simultaneous use of planar adaptive antennas and the HF modem. Improved communications reliability offered in a variety of tactical and strategic scenarios is through the intelligent control of existing diverse communications assets. Multimedia Survivability Experiment effort provides products applicable to TAC, Air Defense, and future adaptive planning functions for SAC. Meteor burst communications offers improvements during high ionospheric absorption events as well as inherent properties in low probability of intercept (LPI). A number of propagation studies intended to characterize links below 300 miles and

modulation schemes will be evaluated with the objective of developing an enhanced modem design for an order of magnitude improvement in burst throughput. Results of the Hardened Antenna Technology program will provide a design handbook for installers to use in building buried antennas in a cost effective manner. The result of this program will be used as a basis for the design of a hardened antenna for the GWEN system. The residue from that program, which includes a complete measuring system for antenna evaluation, will be used for an evaluation of specific low profile, high angle system for the TACP.

**TACTICAL COMMUNICATIONS NETWORKS** - The goal is to develop a sensor internetting capability which will provide a communications/processing function to improve the quality of the air picture developed by the Tactical Air Control System. The first of these efforts, Burst Comm Modem, will build and demonstrate the capabilities of a communications processing function which is integrated into the radar timeline. The results of this effort will develop a processing capability which can be added to the existing tactical ground surveillance environment to provide track correlation and communications interface between AN/TPS-43E2/ULSA/MCE environment. Multi-Level Secure (Multi-Media Integrated Service Node) will be developed in accordance with the objectives of PT-14. This area will address, through a number of efforts, Tactical MLS gateway technology, Security in a Tactical Multi-media tiered Network and Internetwork protocol issues. Technology base for advanced concepts in AJ/LPI Air-to-Air/Air-to-Ground Communications will be developed. Short range Intra-flight communications and possible enhancements to waveforms such as JTIDS will be demonstrated during FY88-89. AFWAL will be receiving copies of this Advanced Development Hardware for incorporation into their LPI Brassboard program which is an input into the ICNIA Advanced Technology Terminal. The second part of this program will be to develop a AJ/LPI Transceiver which takes advantage of the performance improvements possible through the use of Acoustic Charge Transport Technology (PT-09). The third part of this program will be to develop a Tactical Integrated Radio Network which will provide AJ/LPI Line-of-sight and Beyond Line-of-sight Media Control. Adaptive Spatial and Temporal signal processing and multiband RF technology. Operation in both classical and innovative frequency regiments are contemplated. Deceptive C3CM techniques to mask the location of radiating elements through the physical dispersal of antenna elements, and the concomitant reduction of observed signal power from any one element will be developed and demonstrated. Virtual Source Technology will first be investigated through simulation and then followed by demonstration.

**WORLDWIDE COMMUNICATIONS.** The goal is to develop communications techniques and technology which will enhance information transport connectivity for global scale users. Emphasis is on the Defense Communications System (DCS) via developments supporting security protection and internetworking, on the MILSTAR system via developments supporting airborne terminal enhancements and on the Defense Satellite communications System (DSCS) via advanced high speed processor developments. In support of the DCS, FY89 will see the certification of

the Multinet Gateway, providing a multi-level secure internetting capability, and the initiation of the Survivable Integrated Communications Control capability, intended to provide a new restoration and reconstitution control capability for Subregional Control Facilities and selected control positions in the theater Area Communications Operations Centers. Combining with the development of a true integrated voice and data transmission capability, these efforts will culminate in the development of an Advanced Communications Node, which will provide a survivable, secure, transportable capability to access and generate information consistent with any position within the DOD hierarchy. For enhanced airborne MILSTAR terminals, a fiber optics based capability will be provided. This has the potential for considerable reduction of EMI and EMC problems by being able to distribute the millimeter wave subsystems throughout the aircraft rather than being grouped in the proximity of other high power RF sources. A long term program aimed at insertion of MMIC technology enhancements will be initiated. Exploration will begin into the possibility of using higher millimeter wave frequencies and into the application of VHSIC II for implementing signal processors. These efforts will be tied together through a new, system oriented, advanced development project which will provide hardware for test and evaluation.

**ELECTROMAGNETICS** - The Electromagnetics thrust will develop technology for the generation, control, processing and radiation of rf, microwave and millimeter wave energy for C3I systems. An important part of this program is the characterization and development of system design models for target scattering, ground scattering and other forms of surveillance radar clutter, and propagation conditions which enable novel forms of surveillance and communications. The program is organized around the major disciplines of target and clutter, electromagnetic scattering, monolithic microwave and millimeter wave integrated components (MMIC), antennas and electromagnetic wave propagation. The scattering area will provide target and clutter models for surveillance radar design stressing bistatics and wide-bandwidths. Array antenna radar cross section control, and the associated problems of radome design, such as one way radomes, and near field measurements of scattering will be addressed. The MMIC Component area will provide new, inexpensive components such as phase shifters for surveillance radar and communications systems. Special stress will be placed on millimeter wave components. The technology will emphasize wafer level union techniques for providing digitally controlled components and photonic techniques for new methods of signal generation and control, such as laser switched components. The Antennas subthrust stresses Smart Skin structural antenna technology and the associated control technology for extremely large, flexible distributed arrays. This technology is essential for multi-function, multi-frequency digital beamformed antennas capable of adaptive radar, ESM and communications. EHF monolithic array technology will build upon near term developments in hybrid scanning techniques and be used in MILSTAR aircraft terminals and space communications systems. These arrays form a unique union of printed circuit and monolithic component technologies. The Propagation area provides characterization and system design models for new HF long range radar and communications and



microwave/millimeter wave communications systems. An example is ionospheric ducting for providing long range surveillance of missile launches. Submillimeter or Terahertz systems employing new high temperature superconducting materials will be developed for space radar and communications.

**Antennas** - The goal of the antenna subthrust is to develop a technology base applicable to ground, airborne and space based radar and communications antenna systems. Emphasis is on advanced phased array and multiple beam antennas. Technology areas range from fundamental developments such as broadband and multi-band apertures and low sidelobe feed technology to advanced control methods in support of fully adaptive arrays. An important growing area is the development of technology for advanced airborne conformal, multi-frequency, multi-function arrays. At UHF and SHF frequencies, Project Forecast II Smart Skins Programs address the development of large, conformal airborne arrays and the control and distribution of RF energy for these arrays. Longer range efforts under Smart Skins will address advanced concepts for array "self-healing". At EHF frequencies, developments are dominated by the high technology tasks of integrating array elements, rf, dc and control circuitry into monolithic "subarrays" that include a number of elements, amplifiers and phase shifters on monolithic gallium arsenide substrates. Project Forecast effort PT-15 "Adaptive Control of Ultra-Large Arrays," is demonstrating computer controlled beamforming techniques for transmit arrays, techniques for reducing the processing time for adaptive beamforming in receive arrays, self-cohering techniques in large distributed arrays and array self surveying techniques.

**Components** - The components subthrust furthers development in the areas of new microwave/millimeter wave components which are critical to the operation of C3I systems. These include phase shifters and time delay units which limit the affordability of wideband phased array antennas. GaAs components technology will be developed to reduce the size and cost of frequency synthesizers. Digital and analog circuits will be combined with optical circuits on the same chip to meet the objectives of PT-10, "Wafer Level Union" and provide photonic controlled components. The impact of high temperature superconductivity for lowering the loss of MMICs will be assessed.

MMIC phase shifters are required for reliable, affordable phased array antennas in both surveillance and communication systems. These phase shifters offer small size and zero insertion loss independent of phase setting. Frequency synthesizers capable of rapidly hopping over a wide range of microwave frequencies are being developed using advances in low loss bulk overtone acoustic resonator technology.

**Scattering** - The goal of the Electromagnetic Scattering subthrust is to develop new analytic methods for the determination of electromagnetic scattering from terrain and other forms of microwave and millimeter wave clutter. Measurements and supporting analyses of clutter, electromagnetic foreground effects, and related environmental scattering are being performed. Stress is being placed on bistatic and

wide-bandwidth effects. Techniques to analyze, measure and model scattering from complex structures including lossy materials, frequency selective surfaces, antennas and radomes are being developed. Antennas and radomes with reduced scattering cross section to preserve platform low observable capabilities are also being developed under this subthrust. The main emphasis is on the scattering phenomena from shaped targets made of lossy absorbers designated as low observables, on scattering from both airborne and ground based antennas, on problems of the physical environment, and on the implications of these phenomena for radar detection.

In the electromagnetics of scattering from lossy dielectric materials, analytic and numerical calculations, plus experimental measurements are applied to the problem of detection of low observables. A data base of monostatic and bistatic scattering properties is urgently needed for radar system detection and tracking of low observables. An analytical effort to develop models of scattering from rough surfaces for a variety of terrain types, to make measurements to provide calibrated clutter data for a data base to use in detection, and to verify model predictions, addresses the degradation of radar performance in detecting and tracking low observable, low altitude targets due to both clutter and multipath. A program to reduce antenna cross sections while preserving antenna performance is continuing. The characterization of physical terrain permits the calculation of multipath reflections and their effects on radar performance and allows scattering models and prediction of multipath and clutter in real time to be achieved.

Propagation - The Propagation subthrust consists of investigations that are directed toward overcoming the limitations imposed by the troposphere on microwave and millimeter wave systems, and the effect of the ionosphere on OTH radars and communications systems. Emphasis is placed on the exploitation of ionospheric ducting for long range surveillance and ionospheric limitations on advanced OTH systems. The work includes investigations on terahertz technology, including superconducting sources, detectors and radiators for millimeter and submillimeter wave sensors.

Low Frequency efforts assess propagation during disturbed ionospheric conditions and include an investigation of the survivability and jamming vulnerability of LF signals radiated from aircraft. Previously specified high-altitude propagation parameters are being applied to propagation models for the evaluation of communication reliability and survivability. HF Survivable Communications is receiving increased emphasis with efforts addressing high-altitude survivability and wideband availability. In the VHF spectrum, the survivability and availability of meteor burst propagation is being investigated. SHF/EHF Propagation Programs are being conducted to determine the limitations imposed by the troposphere on microwave and millimeter wave C3 systems. Theoretical and experimental work is proceeding to improve troposcatter models and to investigate frequency dependency troposcatter.

Propagation work in the area of surveillance involves the detection of

targets by means of EM radiation in the radio portion of the spectrum from VLF through microwave frequencies with emphasis in HF. Characterization of ionospheric clutter and its suppression for increased effectiveness of OTH radar systems are being pursued. Spatial and temporal statistical properties of auroral radar scatter are being measured with the aim of developing adaptive clutter rejection techniques.

**SOLID STATE SCIENCES** - The Solid State Sciences thrust provides for developing the technology necessary for signal processing devices, electro-optical devices, electromagnetic device materials, and electromagnetic radiation hardening of devices for present and future electronic C3I systems.

Components such as short cavity lasers, quantum well bases, low loss fibers, and modulators that operate at very high modulator rates are being developed for future military fiber optic systems. High purity materials with tailored properties such as quartz, indium phosphide and its alloys and fluoride glasses are developed for application to time and frequency devices. Signal processing and sensing devices developed will lead to more capable battlefield sensors and space object detection systems with reduced cost of ownership. Research in radiation hardening of devices and components will ensure C3I mission sources in nuclear and space environments.

**SIGNAL PROCESSING DEVICES** - The Signal Processing Devices subthrust is directed towards the development of advanced infrared imaging sensors for C3I systems. The goals of this subthrust is to develop new IR surveillance sensors. Current silicide arrays have useable spectral response between 1 and 5.7 microns wavelength. The principle silicide detector is a platinum silicide Schottky diode on p-type silicon. This effort is directed towards improving the emission efficiency of P+Si and towards extending silicide sensor photoresponse into the LWIR spectrum between 8 and 20 microns. Most infrared systems are based on small detector arrays (60 to 1000 detectors) which require mechanical scanning for imaging or for wide field surveillance. This effort takes advantage of the high producibility of silicide devices to realize very large IR focal plane arrays, 250,000 to 300,000 detectors per chip in FY89 and up to 1,000,000 detectors per chip in FY91. These arrays will provide the basis for high definition staring surveillance sensors and FLIRS and "strap-down" seekers for guided missiles. RADC and AF/IAL are conducting year round/day night tests of both silicide and conventional IR imaging systems. To date, these tests have shown MWIR thermal imagery, fully comparable with that of the LWIR band. Silicide sensors have resolved thermal detail with differences as small as 0.02C. Important target signature data has been observed using silicide sensors in the MWIR band.

**ELECTRO-OPTICAL DEVICES** - The goal of this subthrust is to investigate and develop Photonic device and device processing technologies. Silicon waveguide devices, surface emitting lasers and indium phosphide processing technologies are to be included. High modulation rate lasers are to be developed to control phase arrays and

MIMIC circuits. Optical fiber delay lines will be developed as broadband signal processing elements. Photorefractive and non-linear optical materials will be developed for spatial light modulator and four wave mixing media. Adaptive optical correlator will use phase only filters. Real time optical processor will be developed for pattern recognition.

**ELECTROMAGNETIC MATERIALS** - The goal of this subthrust is to develop high purity, low dislocation single crystals for growing substrates in the preparation of epitaxial and ultrastructure type layers for use in photonic applications and microwave devices. High quality quartz has been developed with improved radiation hardness for advanced C3I frequency and timing devices. New possible superconducting materials will be investigated for use in high speed (terahertz) devices. Heavy metal fluoride glasses will be fabricated and evaluated as radiation hard IR fibers and non-linear materials for photonic devices. Large glass mirrors are being fabricated for SDI applications.

**DEVICE RADIATION HARDENING** - The Device Radiation Hardening Subthrust supports the development of a radiation-hardened electronic technology base and provides technology assessments to AF system offices. The program in this subthrust is centered around LSI memories and digital logic circuits. Radiation induced failure modes are identified to support the hardening program and to provide data on advanced technology to SPOs. Demonstration circuits hardened to satellite radiation specification levels will be fabricated and tested to show progress and prove the compatibility of hardening techniques used with standard circuit fabrication methods.

**INTELLIGENCE** - The Intelligence thrust is broken into five subthrusts. They are wideband recording, speech processing, knowledge based intel systems and C3I data base technologies are required for the timely processing, storage, retrieval and dissemination of extremely high volume and data rate digital information.

**WIDEBAND RECORDING** - The wideband recording subthrust will develop the necessary technology base for the timely recording, storage and retrieval of high data rate, large volume intelligence data. Multidisciplined approaches are being exploited to meet the continuing explosion of data being generated by advanced sensors in both Tactical and Strategic Intelligence missions. A three dimensional, photon gated memory approach is being exploited to provide micro to pico second access to over 10 trillion bytes of on-line storage all housed into a 10 cubic centimeter photopolymer storage block. Optical digital disk technology will be transitioned into a 6.3 program to provide a suite of optical disk capabilities for airborne applications. The Wideband recording subthrust will continue the 6.3 Tactical Optical Disk (TODS) project in FY88 to provide an integrated suite of transportable digital optical disk systems that will exploit for the first time an erasable, 300 megabyte 5 1/4 inch disk, a 5 gigabyte 14 inch disk and a 30 gigabyte mini-jukebox to MIL-E-5400 Specifications. Under the 6.2 program, technology verifications of magnet-optic tape systems and wideband single dimensional Spatial Light Modulators will be demonstrated. With the

recent emphasis towards Photonics in FY89-92, this thrust will initiate technology developments in 3-dimensional optical memories, optical cache memories, and a hierarchy of memory devices for optical signal processing for optical computing applications.

**SPEECH PROCESSING** - The Speech Processing R&D program is concentrated in three major technology areas: Narrowband Communications, Data Entry/Control and Speech Enhancement. In the narrowband communications area, technology is being developed to provide jam-resistant communications that is from 10 to 100 times more difficult to jam than current communications systems. Technology in the Data Entry/Control area, will solve man-machine interface problems for existing COMINT and battlefield management stations and for future systems such as the FORECAST II Super Cockpit and Battle Management Processing and Display Systems. The Speech Enhancement area is addressing contaminated and degraded speech which is a major problem in voice transmission and reception.

**KNOWLEDGE BASED INTELLIGENCE SYSTEMS** - This subthrust will develop and demonstrate advanced knowledge based systems for the purpose of monitoring, tracking and identifying foreign space launches prior to orbital injection. Efforts include knowledge acquisition, knowledge based development, calls to conventional application programs and man-machine interfaces. Technology developments include knowledge based inferencing, data processing, multiple data analysis, real time processing, advanced design concept and demonstration. In this area, developments will be directed to study, demonstrate, and prove application feasibility of the knowledge-based systems technology to aid the intelligence analytical process. In addition, emphasis will be placed in Artificial Intelligence technology deficient areas or emerging areas, as initial application technology matures. In the area of Artificial Intelligence, techniques such as knowledge acquisition, knowledge representation, and knowledge engineering will be applied to operational functions such as space/missile foreign launch assessment, space object analysis, and long range air assessments. Integration and evaluation of the Intelligent Analyst System (version 2), development components will begin. In the FY88-91 time frame, technology issues will address generic shell architectures for systems, new algorithms for natural language data base generation, and the investigation of neural networks for innovative learning in the intelligence assessment environment.

**C3I DATABASE TECHNOLOGIES** - This subthrust area involves the development of technology to improve database responsiveness, ease of use, administration, knowledge base interaction, and interoperability. Advances in object oriented data base techniques, information resource dictionary systems, artificial intelligence, event and concept tracking, and data flow architectures are rapidly changing the role, architecture and functionality of the database. Work will continue in the key areas of database generation, database interoperability, database/knowledge base interoperability, information security, and information representation.

Current efforts demonstrate domain dependent feasibility in the specific areas of space foreign launch, long range air, and JINTACCS. Technology development include extending the software baseline (control and man-machine interface) to become domain independent so that all types of messages can be processed.

**RELIABILITY & COMPATIBILITY** - The Reliability and Compatibility Thrust is divided into two subthrusts: Solid State Devices and Equipment/Systems. The Solid State Devices subthrust develops quality and reliability assurance techniques for very large scale Integrated Circuits (VLSIC) and Monolithic Microwave Integrated Circuits (MMIC) as well as improved electrical test procedures. The technology to assure the availability of reliable solid state devices for Air Force and DOD electronic systems (i.e. Advanced Technical Surveillance Radar, Advanced Airborne Surveillance Radar, Space Based Radar, etc) is also being developed in this subthrust. The Equipment/Systems subthrust develops reliability, maintainability and testability techniques for the development of military systems with improved operational readiness and supportability. Areas of emphasis include the utilization of computers to testability (CADBIT), application of artificial intelligence techniques to system maintenance (SIARTBIT) and development of techniques to improve system diagnostics and failure prediction (Time Stress Measurement Device).

**SOLID STATE DEVICES** - The Solid State Devices Subthrust is divided into two areas: the first being concerned primarily with complex silicon VLSI, mainly digital devices, and the second concerned primarily with gallium arsenide microwave solid state devices applied to microwave T/R modules, communications, etc. The first area, QRA techniques and testability, involves the assurance technology of complex VLSI/VHSIC from the establishment of standard test methods, physical and electrical, new qualification methods, improved testability employing built-in test at the device level, improved screening methods, failure mechanisms studies, etc, which are applicable to PF 11, PT 48 and PT 11. There is a need to increase the sensitivity and accuracy of our present and new analytical techniques for assessing the long term reliability potential of these devices. Work in wafer scale integration, reliability will concentrate on evaluating the packaging technologies essential for packaging five inch diameter wafers containing potentially millions of transistors. The second area involving microwave solid state devices continues to evaluate integrated monolithic gallium arsenide modules including reliability evaluation, standard test methods, qualification methods, and supports both SDI and MMIC programs. The reliability and performance evaluation of HEMT (Hi Electron Mobility Transistor) devices will continue.

**EQUIPMENT/SYSTEMS** - In the Reliability/Maintainability/Testability design area, Hardware/Software System Reliability Prediction and Assessment will fill the void in the technology for assessing the reliability of AF systems containing both hardware and software. The results will provide reliability analyst system developers with a capability to specify, predict and control the reliability of combined hardware/software systems. ATE Expert System Technology will use expert

system and artificial intelligence techniques to automate the generation of automatic test equipment (ATE) software. Payoffs will include increased operational readiness (from increased availability of spare parts) and reduced maintenance costs. In the Logistics RD area, four existing efforts will be continued. These include Marginal Checking, Testability Encyclopedia I and II and Computer-Aided Tailoring Software Program. In the area of SMART BIT, an effort to increase the performance of Built-In-Test (BIT) relative to false alarms and intermittent faults, including a laboratory demonstration, will be continued. In addition, a new contractual start, SMART BIT Technology Assessment, will provide the capability to properly assess the compatibility and utility of advanced BIT and TSM (Time Stress Measurement Device) technologies will be investigated. In the area of TSM, funding will continue the program underway to develop a TSM module, flight test it and attempt to correlate failure data with accumulated stress history. A follow-on program to miniaturize the TSM module to the size of an integrated circuit package has been proposed under the RAMTIP Program (Reliability and Maintainability Technology Transition Program).

COMMAND AND CONTROL TECHNOLOGY - The Command and Control Thrust has two subthrust areas entitled Advanced C2 Environment and C2 Technology Lab. The overall objective of these subthrusts is to develop systems that automate and streamline the Command and Control process.

ADVANCED COMMAND AND CONTROL ENVIRONMENT - The Workstation Development and Demonstration effort will examine the architecture and framework of the Battle Management Workstation of the 1995+ timeframe. It began (FY87) with an in-house analysis to identify potential areas of interest and problems in preparation for the contractual phase of the effort. The primary output of the contractual phase will be a technical report laying out possible future architectures and technology paths to follow to achieve those architectures. Demonstrations of some features of the proposed workstation architectures will be accomplished. These architectures will be transitioned to the Workstation Prototype.

a. The Workstation Advanced Techniques effort will examine near term developments to enhance workstation capabilities, specifically focusing on display techniques such as 3-D displays. This effort will go beyond the traditional view of using 3-D to show spatial data and examine the use of 3-D to display other types of data, improving the assimilation of the data. The final product of this effort will be a delivered demonstration of the effectiveness of a 3-D display system to the battle commander. Use of these advanced techniques will be incorporated in the Workstation Development and Demonstration and transitioned to the Adaptive Interfaces.

b. The Workstation Prototype effort is to integrate generic workstation technologies into a hardware environment in which RADC can explore the synergistic effects of multiple C2 technologies. This effort is being pursued in-house to integrate new technologies into the prototype as they become available. The results of this effort will be used to improve the CCTL environment and as background for the 21st

Century TACS. A second generation workstation environment (Advanced Development Model) will be developed using the result of this and other efforts.

c. The Adaptive Interfaces effort will explore user interfaces that can adapt themselves to a particular user. Using expert systems and AI learning technologies, this effort will examine the use of interactively modified user templates that react to user, level of command, task, and context in order to provide the appropriate information in the proper format. The adaptive interface techniques developed will be integrated into the workstation prototype.

d. The Holography Technology effort will produce a demonstration of the use of holography in a battle management situation. The effort consists of the development of improved holographic display technology, providing a final demonstration of the technology. This work will ultimately become part of the Workstation Prototype.

e. The High Resolution Flat panel effort will investigate the technology needed to expand the size of high resolution flat panel displays. Current technology has produced very high resolution displays, but of small size (5" x 5"). Ultimately the developed display will be delivered to RADC for integration in the Workstation Prototype.

f. The Plan Analysis effort will use Knowledge Based techniques to develop a system that is capable of analyzing enemy intentions based on such things as troop movement, known enemy doctrine, enemy and friendly strengths and weaknesses, etc. The demonstration resulting from this effort will be included in the Advanced Development Model.

g. The Voice Input/Output effort will combine existing natural language techniques with existing voice recognition capabilities to produce an interface that responds to spoken commands. Both input and output will be examined. This capability will be integrated into the Advanced Development Model.

h. The Distributed Wargaming effort will look at the feasibility of using distributed systems technology and distributed AI technology to build an AI based, distributed wargaming capability. This ability will allow commanders to participate in war games from their home station, performing their normal battle management tasks, and running the results against a faster than real time, intelligent simulation. Going beyond that, this capability will allow commanders in wartime to construct their plans at geographically distributed, survivable locations and test them for effectiveness using the faster than real time simulation. Distributed wargaming will be incorporated into the Advanced Development Model.

i. The Distributed Processing Security effort will develop new techniques for maintaining security of information on a distribution processing system. It will result in a demonstration of a distributed, secure operating system for inclusion in the Advanced Development Model.



j. The Advanced Development Model effort will combine past and present efforts into a single, integrated environment. The revolutionary aspect of this effort will produce a highly advanced workstation environment significantly ahead of other contemporary workstations. The evolutionary aspect of this effort will allow it to incorporate new developments as they become available, making it a testbed for new workstation technologies. This work will eventually transition to the Advanced C3I Workstation.

C2 TECHNOLOGY LAB - The Command and Control Technology Laboratory (C2TL) provides the necessary facilities to host numerous research and development projects addressing C2 operational deficiencies and future requirements. In addition, it is the key node for electrically connecting together Center wide laboratory assets to more effectively demonstrate the utility of C3I technology products to the user. The funding profile associated with the C2TL Facility Support line provides resources for maintenance of ADPE hardware and software systems within the Laboratory to support the above processes. The C2TL will play a major role in the following technology work.

a. DECISION AIDS. Under Decision Aids, technology resulting from previous AFOSR and DARPA supported work is being applied in the TEMPLAR (Tactical Expert Mission Planner) program. The TEMPLAR program is providing incremental prototypes to HQ TAC with the final product a robust mission planning support tool with real world data/communication interfaces. The C3C1 aid which supports Electronic Combat planning will be transitioned along with TEMPLAR into the Tactical Air Command's Contingency TACS Automated Planning System (CTAPS). The Advanced Planning System (APS) will allow the advanced capabilities of TEMPLAR and C3C1 to transition into the evolving TACS in FY90. The Advanced Analysis Aids program includes follow-on developments from earlier 6.2 efforts and will produce aids such as the Identification of Command Control Operations Nodes (ICON) and Expert System for Air Order of Battle Update (ESAU). These programs are also test cases in response to an Electronic Systems Division request to examine the feasibility of direct transfer to a user of a 6.3 software product. The Advanced TACC development of the technology baseline for a futuristic (year 2010) TACC program will provide the means to apply advanced concepts to the development of the technology baseline for a futuristic (year 2010) TACC offering major improvements in operational effectiveness. The ATACC will employ a decision aided, modular netted system approach aimed at a Kernel TACC of about 20 people. The Adaptable Expert Aid will take advantage of capabilities from both the RADC decision aids efforts and a proposed Joint Service program under the Joint Directors of Laboratories which will provide the capability for an aiding structure which is responsive to changing users, doctrine, scenarios, etc. and allows adaptation to change versus the somewhat static structure found today. The Decision Aid Development Support Environment (DADSE) will provide the standards, tools, hardware/software environment to support future decision aid development and evaluation which allows iterative on-going user interactions. Graphic Systems Representations (GSR) will provide a

framework which can be used for the development of standard advanced graphics/pictorial capabilities in work stations used for implementing our future decision aids. This program will also support the Project Forecast Advanced Processing and Display Program (APADP). The Man-Machine Integrated Model (MIM) program will extend capabilities from GSR, the RADC/DARPA Integrated Multimedia Interface program, the APADP and Army programs in analytic graphics into a standard modular approach for Man/Machine Interaction. The Advanced MMI will develop the prototype capability which will support follow-on system needs. The Heuristic Route Optimization (HERO) program offers a new approach for route planning through a high threat environment that digresses from the current dynamic programming-oriented approach to an artificial intelligence-oriented system. The Dynamic Aiding program will provide the basis for incorporating the GSR, MMI and HERO work into the design of advanced aiding capabilities which can also utilize realtime simulation.

b. DISTRIBUTED SYSTEMS/DATABASES - Work in this area includes a C2 Functional Analysis which represents functional analysis efforts that will document the functions performed, and information flow which occurs within the Tactical Air Control System (TACS). The information developed will be incorporated into an automated system requirements definition system that can be used to support the design of a functionally distributed TACS. A Distributed Elements Design (operations module with ADPE support) will support the functional distribution and physical dispersion requirements of the Twenty First Century TACS. This effort will focus on functional design and integration of modular hardware and software components rather than a specific hardware systems design. Work will also include Distributed C2 Environment/Data Base Management System (DBMS), and Survivable Tactical C3 Testbed initiatives which will develop and integrate hardware and software products to demonstrate the feasibility and supportability of a distributed Tactical C2 System using distributed relational databases, and existing tactical communications. A System Control Software effort will identify and develop capabilities required to insure distributed databases based on commercial Database Management Systems, and Operating Systems provide the required capabilities. The support software must insure multiple copies of data maintained at dispersed C2 elements remains consistent, proper data access control can be maintained, and functional migration (a capability to move a function from one facility to an alternate, or to duplicate that function at another facility) can be supported.

Scenario Generator Design, and Scenario Generator Development efforts will design and develop a scenario generation and modeling capability that will be required to demonstrate, test, and evaluate the prototype functionally distributed, physically dispersed, and highly automated 21st Century Tactical C2 System. DoD investment in existing modeling and simulation systems will be evaluated as the requirements are better defined through the design efforts.

c. STRATEGIC APPLICATIONS - The overall objective of this area is to develop and apply AI based Adaptive Planning, Distributed Information Processing, and Survivable Communications technologies to support

survivable and adaptable SIOP planning in a pre-, trans-, and post attack strategic environment. Joint efforts by RADC, SAC, JSTPS, and DARPA are being pursued. In addition to the developments being pursued within the SAPE program products emerging from companion 6.2 and 6.3 efforts will also be utilized.

The Distributed AI Planning effort is a technology based program to investigate concepts for distributed, cooperating planning agents which are physically dispersed across multiple computers. The effort will investigate, in the context of the SAPE application, what are the interaction paradigms, management of the data, and partitioning of the tools.

The SAPE development program is divided into four phases, the first of which will be a multiple award study to perform detailed analysis and design of the required capability to perform planning for Strategic Relocatable Targets (SRT) in a pre attack environment as well as a limited option replan. The phase 2 implementation will develop a prototype capability to demonstrate this function. The phase 3 will address the planning for the post attack which will be characterized by planning with significantly depleted resources in a sparse processing environment. Major technical issues need to be addressed in AI Planning tools which can incorporate concepts of uncertainty management, in dynamically reconfigurable distributed information processing backbones and survivable, reconstitutable multi media communications.

The testbed will be a physically dispersed set of processing clusters at RADC, JSTPS/SAC, and the contractors facilities. These clusters will be linked by a secure packetized network, and eventually be a multi media network. The testbed will provide developmental support, prototype demonstration and evaluation of the technology products.

The Distributed Processing Cluster/DBMS is the technology base effort which will be tailoring the distributed operating system functionality to support the distributed planning tools and the required database to support them.

The Multi Media Packetized Nets is the technology base program which will investigate survivable communications through the use of adaptable protocols and automatically reconfigurable networks. In this approach the communications system would select, through an intelligent controller, alternate transmission media as the system sustained loss or disruption.

PHOTONICS: The Photonics thrust, engaging in research and development of the new technology in which light or photons, rather than electrons, are used to acquire, transmit, and process information, is comprised of five subthrusts. These subthrusts will be aimed at transitioning developments in optical memory, processing, computing, networks, and transmission. This will fulfill future Air Force needs for devices that are smaller, lighter in weight, and faster than electronic devices that perform the same function. Since the photonics field is still in its infancy, new

materials, processing techniques, and optics technology offer new opportunities to exploit photons to perform functions currently done with electronics.

The Optical Processing subthrust will be developing and utilizing the electro-optical technologies necessary to exploit the inherent speed of certain optically implemented signal processing functions including integral transforms, convolution, and correlation. These signal processing functions will be employed in SIGINT (Signals Intelligence) detection, collection, and processing systems to exploit tomorrow's exotic signals. Technology limits in areas such as Bragg Cells, Spatial Light Modulators, Detectors, and Visible Solid State Lasers will be investigated in terms of their applicability to other areas of electro-optical research besides Optical SIGINT Collection and Processing. Contractual efforts will be used to develop device technology, explore new architectures, and to demonstrate the feasibility of implementing these architectures. Another area within this subthrust is Two Dimensional Optical Signal Processing. The objective here is to advance optical signal processing techniques to information bandwidths of 200 MHz to 1000 MHz. Emphasis will be placed on reducing the overall digital information that must be analyzed by exploiting optical correlation, auto-correlation techniques. Radar/Communications Processing for Phased Arrays is another area within the Optical Processing subthrust. The objective of this program is to develop an optically controlled/implemented phased array antenna system(s) and null steering signal processor(s) for radar and communications systems. Additional goals are to implement radio/radar subsystems (e.g. frequency synthesizers, mixers, filters, modulators) optically. The objective of the Laser Intelligence (LASINT) Program is to develop and utilize the electro-optical technologies necessary to detect, collect, and process emissions from foreign low energy laser systems and high energy systems. The primary focus is off-axis detection and collection. Some planned EDM products include Off-Axis Laser Collection System, Narrowband Tunable Filter, and LASINT Recording System.

The Materials/Devices subthrust will be concentrating on several developments during FY 38 such as low power short (blue) lasers, high modulation rate laser emitters, high modulation rate external modulators, individually addressable laser arrays, and monolithic opto-electronic devices. Planned near term products utilizing semiconductor lasers are a Schottky camera, silicon switches, organic second harmonic generator, and quantum well laser.

The Optical Networks subthrust will develop an integrated high capacity photonic network. This network will be distributed, secure and highly survivable based on extensive interconnections between nodes. The network will be rapidly reconfigurable. Switching and control functions will be distributed. Some characteristics of this network will be that it would have greater than 1000 nodes and would have 1000 independent channels. Some planned products are a tunable optical source, an optical interconnect/switch, a high density optical mux/demux, and a multiwavelength optical LAN. Other work within this subthrust centers

around optical transmission, which will develop a laser transmission and reception system that emphasizes all optical or electro-optic implementation. The goal within this subthrust is to develop all optical or hybrid electro-optical techniques and hardware demonstrations to advance the state-of-the-art to a fully adaptable, highly reliable laser transmission/reception system that can be utilized on a straight forward basis on a variety of platforms. Some planned products are a narrow linewidth source and an optical beam steering system.

The optical computing subthrust will exploit the traditional Von Neumann computer I/O "bottleneck." Optical Computing offers the potential to reduce the overhead of I/O and data movement instruction by their architectural and device innovation which alters the traditional Von Neumann computer concept. The goal here is to develop optical computing systems (architectures) for specific Command and Control applications. Efforts will be conducted in areas such as Very Large Data/Knowledge Base Computing, Optical Neurocomputing, and General Purpose Digital Optical Computing. One of the planned activities includes the design and implementation of a 16-bit programmable central processing unit to serve as a working model of an optical computer. Design will be accomplished in late FY88 and an Exploratory Development Model (EDM) in FY91. Another planned product is the Optical Content Addressable Memory which will access memory by its content rather than by its location address. A feasibility study will be accomplished in early FY89. Design of a Very Large Data/Knowledge Processor with OCAIM will be accomplished by mid FY91.

The Photonics In-House Program will be directed primarily at optical computing/ processing and networks. Initial emphasis is to develop and test an optical computer as soon as possible. A "first generation" optical computer will be assembled from existing components and subsystems. It will be tested to determine limitations so improvements can be identified. The long term goal is to develop an optical computer which is competitive with electronic computers in terms of speed and memory. Near term efforts will focus on components required for an optical computer. One of these efforts involves the development of a model of a bistable non-linear optical system and to test and analyze the model by observing the response of the system to time varying inputs. The in-house program will also involve optical computer system development and test. Subsystems of an optical computer, which will be acquired from companies that have already fabricated them, will be tested individually and integrated with other sub-systems and components to form an optical computer. The in-house program will also include several efforts that will be performed under the ultra fast optical pulsing system. An example of these are the characterization of photonic devices and optical pulse compression. Work in these areas would begin in mid FY88 and continue into FY90.

COMPUTATIONAL SCIENCES - Computational Science thrust has three major subthrusts: Software Engineering, Systems Technology/Distributed System, and Artificial Intelligence/Knowledge Based Systems.

SOFTWARE ENGINEERING - This subthrust is comprised of three technology areas- C3I Support Environment, System Definition Technology and Software/System Quality.

The C3I Support Environment area is concerned with the development, exploitation and technology transition of improved software engineering tools and methods. Work initiated in this area is focused on the development of an integrated software life cycle support environment comprised of an interactive, common user front end, a project and comprehensive set of off the shelf tools. The environment can be tailored to match program size and complexity and will contain numerous tools which support project management, configuration management, and quality assurance. New tools will be added to the environment as they become available. Environment tools to assist in software program management will be developed to provide visibility into the software life cycle process.

An Advanced Life Cycle Impact Analysis System will enable the quantification of the impact of change upon deployed software systems as well as those under development. Previous tools directed at impact analysis have merely dealt with identifying what portions of the software are affected by requirements change, error detection and correction, block upgrades, etc. The objective of this effort is to assess the degree of impact due to such modifications. Program managers will be able to determine the extent to which software must be changed (or possibly rewritten) to accommodate new releases and versions and to arrive at much more accurate cost estimations.

A Project Management System will enable program managers to track software life cycle progress during development and to match effort expended against the work breakdown structure, establish and report on milestone activity, and to conduct critical path analyses. The System will also provide capabilities for software quality assurance and quality control. The environment supports a multiplicity of high order languages including Ada, FORTRAN, COBOL and JOVIAL.

Exploratory development in Software Life Cycle Knowledge Based Enhancements for the Environment itself will define Artificial Intelligence (AI) enhancements for Environment tailoring and subsetting for mission specific applications. The definition of user roles and rule based approaches to the man-machine interface will strengthen Environment responsiveness and ease of use.

Work is continuing on an Ada Test and Verification System (ATVS), a path testing tool, which will be applied during the development of and support to Ada software systems. Numerous reports will be provided by the ATVS to assess test coverage, identify performance bottlenecks, and to assist in the analysis of adding new Ada software modules to a system as well as their interfaces both internal and external. Advanced Ada programming constructs will be supported by the ATVS to provide full spectrum software analysis.

Other area objectives consist of research and development for software technology to support software implementations on distributed and concurrent systems as well as techniques for the design of fault tolerant software. Increasing use of parallel and concurrent machine architectures requires new and improved software engineering technology. An objective of this area is to examine and develop techniques for parallel, concurrent, and hybrid architectures for all phases of the life cycle. An effort to investigate Software Engineering Techniques for Non-von Neumann Architectures will identify critical software engineering shortfalls and needed capabilities. The out-year program will develop and demonstrate applicable tools and methods.

The orderly introduction of AI technology is also being pursued in this area outside the purview of the Software Life Cycle Support Environment, where applicable, and will bridge the gap between the Environment and systems such as the Knowledge Based Software Assistant (KBSA). The Integration of Knowledge Based and Conventional Tools will be pursued such that these life cycle oriented techniques can be introduced into the environment or produced on a stand alone basis. This effort will provide for the augmentation of conventional software engineering tools and methods by knowledge based and expert system technologies which will increase tool capability and/or coverage. Furthermore, user experience with such tools and methods will be retained by the augmented techniques for increasing productivity for like or next system application. Significant improvements in software quality should be realized by combining conventional approaches which are in use at the present time with AI based technology to eliminate or alleviate current software engineering shortfalls.

The System Definition Technology area is concerned with the definition of methodologies and computer based tools for the analysis, specification and validation of system and software requirements. This work is organized around the concept of a Very High Level Language Requirements Environment which is an environment for supporting the research and development of methods and tools, the application of those methods and tools to realistic C3I system and software requirements problems and the evaluation of those methods and tools in terms of the productivity of the processes involved and quality of the products they produce.

Current efforts involve the search and development of a requirements analysis and specification method (CORE), and a set of requirements validation tools based on rapid prototyping. The prototyping tools utilize existing graphics packages and simulation models to quickly build prototypes of problems frequently encountered in the development of C3I systems. They also utilize a very high level language to deal with specific algorithmic aspects of those systems.

The ongoing program to produce a Rapid Prototyping System (RPS) will continue into the Requirements Engineering Workstation Integration effort where the CORE, MILL, and RPS capabilities will be merged, an improved man-machine interface developed, and a scenario generation

capability provided to enable the close collaboration of the prototyping engineer with the mission user. Specific scenarios which reflect mission domain attributes will be quickly generated and modified based on user evaluation and feedback.

Reusable C3I Specifications are being addressed to examine their potential for application to other systems. Instead of code reusability (which may not meet performance requirements) the specifications for similar systems may be decomposed and assessed for reusability of specifications which have been verified and validated under operational conditions. Cost savings and specification quality are primary goals of this work.

Advanced requirements engineering techniques will be exploited in the out-year program and integrated, as required, with the mainstream RPS and Requirements Engineering Workstation efforts. The Specification Tools Environment Integration results will be introduced into the Very High Level Language Requirements Environment.

The Software and System Quality Area is focused on software quality specification, measurement and assessment.

One of the principal efforts in this area is the Software Reliability/Test Integration techniques which will combine software testing techniques such as path testing, symbolic execution, and mutation analysis with reliability assessment. The results of this effort will take the form of a guidebook which will recommend appropriate testing strategies for improving specific reliability attributes to meet mission specific objectives.

A modest effort for Software Quality Methodology Enhancements will examine the theoretical aspects of software quality metrics and form one of the lead in activities for determining Software Quality Effects for Advanced Architectures such as parallel and highly concurrent processing. The software quality metrics for this class of architecture will most probably require new and innovative approaches which relate software quality to performance issues and their inherent trade-offs.

The Software Quality Automated Assistant and its planned enhancements will provide an expert system based approach to specifying software quality factors prior to development and to focus the threshold values for these factors on realizable and measurable metrics. The artificial intelligence technology embodied in the Assistant will enable program and software acquisition personnel to receive expert help in writing software quality specifications. Mission specific inputs for command and control, intelligence etc will be provided by a Mission Area Generation Capability.

The Software Quality Laboratory Definition, Software Quality and Productivity Laboratory, and the Software Engineering Evaluation Facility are all directed at improving software maintenance benchmarking, metrics for Software and System requirements and design phases, measurement



extensions for AI based systems, and facilities for assessing real world software system quality. Quantitative and qualitative assessment techniques will be applied to data collection efforts and the results made widely available through the Data and Analysis Center for Software (DACS). These objectives have been established in response to a lack of capability to obtain software systems of high quality on time and within budget. Software quality analysis during full scale development requires automated technology for determining compliance with software requirements, providing feedback to the developer on product status, and verification of operational software characteristics.

#### SYSTEM TECHNOLOGY/DISTRIBUTED SYSTEMS

The overall objective of this area is to develop and demonstrate multiple host distributed configuration of heterogeneous computing resources interconnected in such a way that they provide single processing entity. The computers are physically interconnected by means of computer of different bandwidth, topology and geographic distribution. The distributed system software which operates across the configuration provides a level of interoperability which supports location transparent access to both data and processes. A user has immediate access to data independent of the location of the data or his location for access. The system supports distributed execution of programs across the configuration and migrates programs and data to support load leveling and survivability. One application model would have command centers implemented by local clusters of such distributed processing resources, and the individual centers interconnected over an internet communications system to support a multi level hierarchal command structure. The system would exhibit increased levels of survivability by being able to dynamically reconfigure around lost nodes or elements and in this way assure that critical mission functions continue to be supported. All of this work is contained in the Project Forecast II, PT-41, Distributed Processing. The objectives of this technology area are:

Within the distributed systems area, the efforts address the development of DOS fault tolerance, and the methodologies to design and evaluate prototypes. The decentralized DOS effort will develop a prototype which exhibits decentralized management of resource allocation, thus eliminating the single point of failure. This is critical to achieving dynamic reconfiguration. In addition it will operate in real time (i.e. time deadlines for the execution of processes will be one of the scheduling parameters). This is the only effort of its type within the DOD and has tremendous potential for applications in C2, SDI, ADI, and Avionics. The CRONUS DOS is prototype development which integrates multiple heterogeneous hosts into a DOS that exhibits internet interoperability, location transparent access to data and processes, and extensibility both of host type and resource set. It has been interconnected via satellite to other locations and will be used for an SDI technology experiment. The fault tolerant efforts are concentrating on development of generic mechanisms and algorithms that can be incorporated into a variety of implementations. All of the prototypes are being integrated into the Systems Evaluation Environment for

evaluation. One of the extremely difficult problems associated with the evaluation is instrumentation and data collection, due to the complex interrelationships that exist among the elements of the system. The instrumentation efforts will develop both the methodologies and the mechanisms for probing and data collection for distributed systems. The technology in certain areas is reaching the level of maturing that operational configurations will soon be undertaken. The tools effort will develop the tools and methodologies for the design, implementation and debugging of distributed systems.

In the database area the emphasis is on the development of data architectures for a number of critical areas. The tremendous activity in the AI and Knowledge Based area have highlighted several deficiencies in the ability of current database paradigms to meet these needs. Efforts are underway to develop the necessary extensions to database architectures to accommodate these needs. New requirements (eg. SDI) and new technologies (eg. special hardware architectures) have identified new demands for handling very large databases. Efforts are addressing not only the size issues but the corresponding issues associated with fault tolerance, consistency and real time access. The Distributed Database efforts extend all of the database issues and paradigms to the multi host environment. Capability is being developed to support both replicated and partitioned data structures, in both a homogeneous and heterogeneous host environment.

RADC has established three objectives which address the technology deficiencies in Computer Security. The first objective is to develop and demonstrate the tools and technology necessary to realize trusted computer systems, with emphasis on security Policy Modeling, Multilevel Secure Data Base Management Systems, Secure Distributed Systems/Networks, and Secure System Design tools. The second objective is to conduct technology demonstrations for selected AF users and SDIO and transition the technology to the appropriate SPOs. Finally, to emphasize the use of formal verification to provide assurance that the security mechanism satisfies the security police, focusing on Ada verification, and tools for verification. These thrusts are currently funded only by NSA and SDIO. The Computer Security program has application to AFSC and could benefit from future AFSC funding support. RADC has a working/funding relationship with three agencies: NCSC, SDIO, and ESD. The support provided to the National Computer Security Center is in the areas of Multilevel Data Base Management Systems, Secure Distributed Operating Systems, Verification Technology, and modeling tools for secure system design. The SDIO is supported by the work done in Secure Data Base Management Systems, Secure Distributed Testbed tools/methods supporting secure system design, Ada verification, and secure mechanisms. The ESD program consists of establishing aids to the evaluation of secure computer systems.

The objective of the parallel computing task is to: evaluate candidate MIMD processing architectures and algorithms based on performance; fault tolerance and security requirements, and develop software development tools for complex parallel processing systems.

While this task is funded solely by SDIO and addresses BII/C3 technology; the work is directly applicable to AFSC processing requirements and would benefit from future AF funding. The objectives of this technology area will be to integrate optical devices, materials, architectures and algorithms with existing electronic computing technologies and data/knowledge based systems; develop a general purpose electro-optical computer which exhibits increased performance (over functionally similar conventional machines) while executing an equivalent instruction set.

#### ARTIFICIAL INTELLIGENCE

Artificial Intelligence Technology is concerned with the development of advanced computer software modeled after human information processing and capable of providing vast improvements in military decision processes and problem-solving tasks of all kinds. The deciding factor in any future military conflict could be the ability to exercise sound and timely expert judgment in the development, employment, and modification of military strategies and tactics. Future Air Force C3I systems, in particular, must have built-in intelligence in order to manage analysis and decision processes currently overwhelmed by information sources and an increasing complexity of required response options. Development of the technology to meet the critical shortfall areas identified in the Air Force AI Investment plan is needed before broad AI exploitation in large-scale, real time Air Force C3I and cockpit applications can be realized.

Although state-of-the-art Artificial Intelligence technology is sufficiently mature for many near-term applications and new generation systems currently under development will significantly extend the applicability of AI, there are still critical technology shortfalls, identified in the Air Force AI Investment Plan, and required in almost every mission area in which the Air Force is attempting to apply AI.

The Air Force Artificial Intelligence program is attempting to achieve the most orderly, efficient and effective development and transition of AI technology into the Air Force inventory for use in complex, robust weapons, support and training systems. The RADC program is focused on the development of AI capabilities for advanced Air Force C3I information processing and decision aiding applications.

The Artificial Intelligence technology area objectives are:

a. AI TECHNOLOGY -- Develop and demonstrate components technologies in advanced reasoning, large-scale systems and intelligent man-machine interaction supporting the next generation of knowledge-based systems for application across the spectrum of C3I domains. Technology development include multi-source, real-time, concurrent and time-oriented problem-solving; reasoning under conditions of uncertainty; qualitative reasoning; knowledge acquisition and management machine learning for C2, and performance evaluation techniques for AI systems and natural language technology for adaptable man-machine interfaces.

b. KNOWLEDGE-BASED DEVELOPMENT TOOLS - Develop and demonstrate knowledge engineering support tools and environment for use in the development of large scale military applications. Technology developments include software architectures for integration of knowledge-based systems with conventional software; enhancements to knowledge engineering environments required for C3I applications; skeletal software shells for addressing generic classes of military applications. i.e., mission planning.

c. KNOWLEDGE-BASED SOFTWARE-ASSISTANT - Develop and demonstrate the use of AI technology in the development and maintenance of large, complex, software and intensive, weapon and support systems. Efforts include each phase of the life cycle as well as the overall framework necessary to coordinate the development process and capture "corporate memory" during the development process. Capabilities developed are aimed at demonstrating increased programmed productivity, improving management assessment and control of software development schedules and cost and increase in system software quality and reliability.

d. KNOWLEDGE-BASED SIMULATION - Enhance knowledge-based system technology to support the development, maintenance and rapid modification of interactive, medium to large scale, intelligent, object-oriented simulation. This technology will be demonstrated through the design, implementation, and evolution of an environment for the construction and utilization of such simulations.

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TPO-5, TITLE: SPECIAL PROJECTS

As the name implies, the projects reported in this TPO are special in nature in that logic does not permit their inclusion in the other TPOs. The projects reported are every bit as important to the Air Force as any other but are of a general test and evaluation or support nature.

SYSTEMS/EQUIPMENT EVALUATION provides for highly instrumented, unique and cost-effective facilities for systems/equipment evaluation. These facilities, which include the Electromagnetic Compatibility test annexes, provide for test and evaluation in support of the improvement of weapon system performance and for the reduction of test, evaluation and modification costs.

The HAVE NOTE subthrust is the Air Force continuation of the DOD Special Electromagnetic Interference Program and provides the Air Force with the capability to determine the electromagnetic susceptibility/vulnerability (EMS/V) of air-launched weapon systems to ensure deployment without mission failure from system degradation caused by radiated electromagnetic energy. It provides the Air Force with an improved test and evaluation (T&E) capability to perform EMS/V assessments on selected weapon systems by integrating an environmental threat analysis, high power radiation measurements, and analysis of special electromagnetic interference, utilizing telemetry, instrumentation and computer simulation.

Ultimately it will provide the Air Force with improved EIR methodology, analytical tools and modeling techniques to insure that the latest lessons learned during HAVE NOTE and other appropriate EIR related T&E are transitioned to weapon systems.

The C3 and Protective Systems subthrust provides for highly instrumented antenna evaluation facilities capable of providing extremely accurate cost effective fine grain data for use in the design and development of C3 and electronic warfare antenna systems.

RADC's highly instrumented antenna facilities include dynamic measurement capabilities on the Precision Antenna Measurement System (PAIS) located at the Verona test Annex and static measurement capabilities at the Newport and Stockbridge Test Facilities.

The PAIS Facility accommodates all aircraft types since dynamic antenna measurements are performed through flight testing. The F-4C, D, and E; EF-111A; A-10; F-15; and F-16 airframes are currently available at Newport for antenna evaluation programs. In addition, C3 antennas and aircraft sections are accommodated. A B-52G airframe is mounted at the Stockbridge Facility and a KC-135 airframe is also available for measurements.

The Techniques and Systems Evaluation subthrust provides for expertise for development and implementation of facilities, techniques,

instrumentation and procedures for test and evaluation through all phases of system definition, development, acquisition and deployment.

RADC possesses specific test expertise and highly instrumented off-base test facilities to support AFSC directed Center managed programs. These capabilities are integrated into matrix management of Center programs which require test and evaluation.

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## FACILITIES

Summary: Over the years, RADC has acquired a number of unique research and development facilities. These facilities, located on Griffiss and Hanscom Air Force Base and throughout New York State and Massachusetts represent a significant investment. As new programs and technologies emerge, they are updated, replaced, and expanded. The major existing facilities are discussed below.

### GAFB: ON-BASE FACILITIES:

Cartographic Research Facility - This facility has been created to determine the effects and interplay of new prototype equipment introduced into the automatic cartographic process. This facility, in fact, simulated a major portion of the cartographic functions, permitting realistic evaluation and improvement through advanced automation, equipments and techniques.

### RADC Surveillance Laboratory (RADSL)

The primary objective of the RADSL is to provide a multi-domain programmable adaptive surveillance radar environment to experimentally and analytically evaluate how the performance of radar systems and processing concepts vary as a function of parametric variation of frequency, polarization, waveform, signal bandwidth, etc. The RADSL presently contains two transmitter-antenna-receiver systems covering the L and S frequency bands 1200 to 3700 MHz. The L-Band is a surveillance system and the S-Band is a dual Polarized Tracking system. An additional system, a Phased Array, operating at C-Band (frequency range from 5.5 to 5.9 GHz) will be installed in early 86. The simulation, analytical and data processing capabilities presently consist of two VAX-11/780 PUS with 4.5 megabyte memory, and a Hewlett Packard 1000 series mini-computer which controls the programmable radar hardware and software.

RADC High Power Laboratory - This facility, a national one-of-a-kind facility, provides for the design, fabrication and evaluation of extremely high power switching devices; pulsers and entire RF transmitters for application to radar and other technologies. A transmit/receive module evaluation facility incorporates the latest state-of-the-art for measurement of module parameters.

Reliability Analysis Center - This facility, used in conjunction with the Equipment/System Reliability and Maintainability program staffed by personnel under contract from the Illinois Institute of Technology Research, is the DOD focal point for the collection, analysis and dissemination of reliability experience information on solid state devices, non-electronic parts and systems/equipment. This DOD Information Analysis Center is funded by the Defense Logistics Agency.

Solid State Device Reliability Laboratory - This complex consists of specialized facilities, each unique in their capability for reliability testing of solid state devices.

The Product Evaluation Laboratory provides for the development and application of the chemical and structural product evaluation methodology required to assess the factors affecting the quality and reliability of solid state devices.

The Failure Analysis Facility is the focus of detailed analysis of microcircuits which have failed during systems acquisition or field operation. In addition, new methods of analysis are developed to permit accurate assessment of the failure mechanisms affecting emerging device technologies.

Facilities are also available for Environmental Stress Testing and Automated Electrical Testing of a wide variety of developmental and mature technology microcircuits. Data generated in these test facilities is used to develop more effective accelerated stress reliability tests, identify device operating limits, evaluate inspection and quality assurance procedures and provide direct guidance to various military electronic system designers and users.

The Microcircuit Testability Laboratory provides RADC with the capability for simulating, testing and analyzing the electrical properties of complex devices. In addition to hardware testing equipment, software tools are used to model device architectures and thereby establish effective reliability testing procedures.

Electromagnetic Compatibility Laboratory - This facility is equipped with a complete line of State-of-the-Art microwave and millimeter wave RF instrumentation equipment and anechoic and reverberation type chambers necessary to support both the exploratory and advanced development and support activities within the Compatibility and Measurement Division. The Electromagnetic Compatibility Analysis Facility (EMCAF) provides a simulated high power electromagnetic radiation environment to support susceptibility/vulnerability testing and analysis of Air Force C3 and weapon systems. The EMCFA consists of a large anechoic chamber and two shielded rooms which house the high power RF sources and signal monitoring equipment. In FY87, a newly developed reverberation (or mode stirred) chamber capability was added to the facility. The EMCFA is capable of testing weapon systems up to 20 feet long over a frequency range of 50 MHz to 18 GHz. All functions including RF sources, instrumentation, and data reduction are under computer control. The EMC laboratory also supports EMI effects measurement and analysis of advanced digital (VLSI/VHSIC) and RF (MIC/MMIC) type microcircuit technologies.

#### RADC OPTICAL ENGINEERING LABORATORY

The OCS Optical Systems Engineering Lab (OSELab) is an applied research facility which performs advanced electro-optical surveillance technology



development, and provides technical program support for the Electro-Optical Surveillance Directorate and other government agencies. The lab supports investigation of basic technology design, fabrication, and testing of optical surveillance subsystems. The current technology thrusts include control of wide field-of-view (WFOV) adaptive optical surveillance devices, optical phased arrays and advanced passive conventional and unconventional imaging systems including sparse arrays. Other thrusts include technology for sparse optical arrays, large optics polishing and surface measurements and demonstrations of adaptive optical systems technology. The lab provides 2000 square feet of space divided into functional areas and interfaces with a VAX/780 minicomputer, Hewlett-Packard 9836-6944 data acquisition microcomputer, a Masscomp MS-560 computer, and single board computers. IMSL, optical design and optimization, optical analysis and interferometric analysis, optical system scattering, system optical quality, and generic and specialized electro-optical system modeling computer codes are available.

#### Command and Control Technology Laboratory (CCTL)

RADC's Command and Control Technology Laboratory brings together a distributed C3I laboratory environment into a test and demonstration capability unequalled at any other Air Force facility. Netted together are specialized laboratories in the Center's Surveillance, Intelligence and Reconnaissance, Command and Control, Communications, and Reliability and Compatibility Directorates.

In the battlefield environment of today and the future, the ability of military commanders to make effective use of continually and rapidly changing information is a critical requirement. At RADC, research is underway to develop artificial intelligence and decision aid techniques to facilitate the information sorting and data manipulation procedures supporting the commander's decision process. This technology is also being integrated into and transitioned through the Command and Control Technology Laboratory in support of strategic, tactical and space battle information management.

The Command and Control Technology Laboratory is a showcase of high-speed computer hardware, including several main-frame processors, high-resolution color graphics, and large-screen displays.

Symbolic processors are used to incorporate artificial intelligence into the demonstration/test and evaluation process. Decision aids implemented on various personal computers are also key ingredients to the process.

Research at RADC will focus on demonstrating technology tools in the Command and Control Technology Laboratory, with the intent of rapidly transitioning these capabilities to potential users for development of, and deployment in, operational systems. Vital to the overall technology development and transition process is effective interaction between the user and the developer in focusing technology directly on operational requirements. The goal and ultimate worth of the CCTL is predicated on this accomplishment.

#### MOBILE COMMAND AND CONTROL TECHNOLOGY LABORATORY:

A mobile extension to the facility, the Mobile Command and Control Technology Laboratory, is equipped with militarized computers, color graphic displays and support equipment. Deployed with this mobile unit is a satellite communications terminal to provide the communications with the Command and Control Technology Laboratory.

The Mobile Command and Control Technology Laboratory can provide an interactive link to operational forces around the globe. The operational user can obtain first-hand experience in state-of-the-art C3I developments available through the laboratory environment. This mobile capability significantly enhances the opportunity for user involvement in the research and development process.

GAFB: OFF-BASE FACILITIES:

Forestport Research Site - This facility contains the VLF Experimental Site which is a unique facility for pursuing survivable communications techniques of vital importance to NEECN.

Newport Research Site - This facility is a truly one-of-a-kind facility which provides for versatile and accurate measurement of free space antenna characteristics. The facility is a combination of several ranges in a relatively quiet radio frequency (RF) environment and in an isolated area away from traveled roads and industrial complexes. RADC has full sized shells of an F-4, F-111, A-10, F-16, F-15, B-52 and B-1 sections available for mounting on 3-axis positioners with their associated antenna systems. A fully qualified evaluation facility at 500 MHz and below for communications countermeasures, satellite communications, communications ECCM and UHF location systems is also available.

Stockbridge Research Site - This facility provides the environment for evaluation of antenna systems installed on large airframes. A full size B-52 airframe is mounted on a single axis positioner with vertical measurement capabilities being obtained by positioning vertically an elevator with receivers on a tower located 200' away. Elevation coverage up to +90 and multiple interrogator capability for evaluation of electronically steerable and phased array antenna systems are inherent capabilities of the range. KC-135 C-130 Air Frames are also available for antenna measurements.

The Northeast Test Area (NETA) is also located at Stockbridge and provides a capability to evaluate Reconnaissance, Seekers, etc. in a Northeast environment. Tactical and Strategic, both Dynamic and Static targets are provided on the range. A B-1 airframe will be added in FY88/89.

Verona Research Site - This is a highly instrumented facility which supports engineering evaluation of C3 techniques, equipment and systems in the areas of ECCM, radar, communications, millimeter wave research, optical surveillance, electromagnetic vulnerability and airborne antennas. Major capabilities include search, height finder, and tracking radar systems; an advanced optical facility; a precision antenna measurement facility; an experimental troposcatter facility, and a data reduction center.

Ava Research Site - This facility houses a unique, high power HF transmitting facility capable of transmitting up to 300 KW (600 KW peak) through fixed Rhombic antennas, and up to 20 KW (40 KW peak) through both fixed and rotatable antennas in the 4 - 30 MHz band with a variety of radar waveforms. A companion wideband/narrowband receiver system is currently installed at the Verona Test Annex. It operates with both an in-house fabricated 12 element Beverage antenna and rotatable lcc periodic antenna. The Ava/Verona HF complex supports a wide variety of

HF radar surveillance and communications testing as well as ionospheric propagation research.

HAFB: ON-BASE FACILITIES:

Materials Synthesis and Development Facility -- This facility contains the most up-to-date equipment, and auxiliary apparatus in the Air Force for the preparation of electromagnetic materials. These include conventional Bridgman, Czochralski, and other well-known techniques, as well as new methods being developed, such as skulling, automated Czochralski, hot forging, CVD, Hydro-Thermal, etc. These equipments, which operate over extensive temperature and pressure ranges, are sited in three special buildings designed with gas leak detectors, blow-out walls, and other safety features. This facility, located at Hanscom AFB MA is devoted to the synthesis and growth of new and/or improved electromagnetic materials for C3 applications and directly supports the device activities of the Directorate.

Radiation Effects Facility -- This facility is a modern, fully equipped laboratory containing major irradiation sources used for the test and evaluation of electronic materials and new prototype devices. This facility consists of a collection of powerful and sophisticated instruments for irradiating materials and devices for the purpose of evaluating the effects of radiation on these devices and their ability to perform to satisfactory military standards during and after such irradiation.

The facility includes a 23 MEV linear accelerator, a 40 kilocurie gamma ray source, a flash X-ray machine, a 3 MEV Van de Graaff accelerator, a 2 MEV high current dynamitron accelerator and other miscellaneous sources. The facility is unique within the Air Force and is involved in a wide variety of studies for systems offices within the Air Force (ARBES, IIX, SATIN IV, MEECN, etc.).

HAFB: OFF-BASE FACILITIES:

Ipswich Electromagnetic Measurement Facility -- This facility is located approximately forty miles northeast of Hanscom AFB and consists of 65 acres and three buildings.

Its mission is threefold: first, to investigate electromagnetic techniques that promise to yield novel antennas and antenna scanning systems of potential value to Air Force communications and radar systems; second, to experimentally investigate the radar reflecting properties of model vehicles and aircraft in order to evaluate their electromagnetic signatures for identification purposes and to experimentally evaluate clutter properties; and third, to provide field test/support for evaluating new electromagnetic sensor concepts.

The site contains an excellent half-mile range for the measurement of microwave antenna patterns. The facility includes an anechoic chamber with a ground screen for precise impedance and antenna coupling

measurements and for investigations of radar reflectivity and signatures of scaled vehicles. The Ipswich Site is excellent for field measurements as it provides a wide range of sea and land clutter environments. The facility has low sidelobe antenna evaluation capability.

Prospect Hill Millimeter Wave Facility - This facility, a sophisticated tropospheric propagation facility, is located approximately five miles south of Hanscom AFB MA. It supports the R&D program on the limitations imposed by the troposphere on Air Force systems operating at microwave and millimeter wavelengths. The effects of the troposphere on propagation are studied so that the performance of millimeter wave earth-to-space wideband data links and terminal guidance systems can be addressed. Prospect Hill is one of the few facilities in the world with a capability to conduct accurate refractive bending, troposcatter and millimeter wave attenuation and emission measurements at elevation angles down to the horizon.

#### Remote Site:

#### Air Force Maui Optical Station

The Air Force Maui Optical Station (AMOS) is an Air Force Systems Command resource managed by RADC and provides measurement support to various government agencies and to the scientific community. The AMOS complex includes the Maui Optical Tracking and Identification Facility (MOTIF) and the Ground Based Electro-Optical Deep Space Surveillance System (GEODSS) which are sensors of the USAF SPACETRACK network. AMOS and MOTIF share resources and are part of a state-of-the-art electro-optical facility which combines large tracking optics with visible and Long-wavelength Infrared (LWIR) sensors to collect data on sub-orbital, near earth and deep space objects. Equipment at AMOS/MOTIF includes 1.2 m telescopes; a 1.6 m telescope; a 0.6 m laser beam director; two 56 cm acquisition telescopes; infrared sensors; a ruby laser; conventional and contrast mode photometers; compensated and uncompensated imaging systems; IR imaging camera; Low Light Level TV (LLLTV) systems; video, alphanumeric, and graphic display equipment; and data processing systems. AMOS unique measurement capabilities and geographical location makes it an excellent site for observing out-orbital vehicles and rocket experiments launched from Vandenberg Air Force Base (VAFB).

The following other existing facilities complement the major RADC facilities:

AMOS has been instrumental in several successful Strategic Defense Initiative demonstration experiments. The complex continues to expand its sensor suite and support to DOD agencies.

#### GAEB

Reconnaissance Exploitation Facility, Experimental Photogrammetric Facility, SIGINT Support Facility, Advanced Sensor Exploitation Facility.

Speech Processing Laboratory, Advanced Optical Test Facility, Integrated RF Communications Laboratory, Command and Control Guidance Test Facility, Digital Communications Switching and System Control Facility, Adaptive Array Laboratory, Satellite Communications Experimental Facility, Digital Microwave LOS Transmission Range, Experimental Tropo Scatter Range, R&D Computer Facility.

#### HAFB

Radiation Hardened LSI/Microprocessor Characterization Facility, Experimental Device Fabrication Facility, Electro-Optical Facility, Materials and Devices Characterization and Evaluation Facility, Frequency-Time Test Facility, Microwave Acoustics and Magnetics Fabrication Facility, Antenna Test Range, Speech Research Facility, COMSEC RDT and E Facility.

TABLE 1

## RADC TECHNOLOGY PLANNING OBJECTIVES (TPO)

## TPO 1 - C3

	RADC DIRECTORATE
A. COMMON C3	
1. WORLD WIDE COMMUNICATIONS	DC
2. COMMUNICATION SECURITY	EE
B. STRATEGIC C3	
1. STRATEGIC COMMUNICATIONS	DC
2. SURVIVABLE C3	CO
C. TACTICAL C3	
1. TACTICAL COMMUNICATIONS	DC
2. SURVEILLANCE	OC
A. ADVANCED TACTICAL SURVEILLANCE RADAR	OC
B. ADVANCED AIRBORNE SURVEILLANCE RADAR	OC
C. SENSOR FUSION	OC
D. SYSTEM SUPPORT	OC
3. COMMAND AND CONTROL	
A.	
B. TACTICAL EM	CO
C. DISTRIBUTED C2	CO
4. INTELLIGENCE	
A. SIGINT EXPLOITATION	IR
B.	
C. COMBAT SENSOR MANAGEMENT & CORRELATION	IR

D. ELECTRONIC COMBAT	
1. C3CII	IR
 TPO 2 RECCE/INTEL	
A. SURVEILLANCE	OC
B. CORRELATION/FUSION	
1. DATA HANDLING	IR
A.	
B. ANALYSIS & CORRELATION	IR
C. DOD I&W	IR
D. IDHS	IR
2. IMAGERY EXPLOITATION	IR
3. PRECISION GUIDANCE & STRIKE PRODUCTS	IR
 TPO 3 STRATEGIC SYSTEMS	
A. ATMOSPHERIC SURVEILLANCE & WARNING	
1. SPACE BASED RADAR	OC
2. LOW OBSERVABLE SURVEILLANCE	OC
3. INTEL/SPECIAL RADARS	OC
B. SPACE SURVEILLANCE & WARNING	
1. ELECTRO-OPTICAL SURVEILLANCE	OC
2. DUCTED IONOSPHERIC PROPAGATION	EE
C. SDI	



- |                 |    |
|-----------------|----|
| 1. SATKA        | OC |
| 2. DEM          | OC |
| 3. BIM/C3       | CO |
| D. ADI          |    |
| 1. SURVEILLANCE | OC |
| 2. BIM/C3       | CO |

TPO 4 TECHNOLOGY - C3/COMPUTATIONAL SCIENCES

- |                                |    |
|--------------------------------|----|
| A. SURVEILLANCE                |    |
| 1. SIGNAL PROCESSING           | OC |
| 2. SIGNAL GENERATION & CONTROL | OC |
| B. COMMUNICATIONS              |    |
| 1. ADAPTIVE SIGNAL PROCESSING  | DC |
| 2. NETWORKING TECHNOLOGY       | DC |
| C. ELECTROMAGNETICS            |    |
| 1. ANTENNAS                    | EE |
| 2. COMPONENTS                  | EE |
| 3. SCATTERING                  | EE |
| 4. PROPAGATION                 | EE |
| D. SOLID STATE SCIENCES        |    |
| 1. SIGNAL PROCESSING DEVICES   | ES |
| 2. ELECTRO-OPTICAL DEVICES     | ES |
| 3. ELECTRO-MAGNETIC MATERIALS  | ES |
| 4. DEVICE RADIATION HARDENING  | ES |

E.	INTELLIGENCE	
1.	WIDEBAND RECORDING	IR
2.	SPEECH PROCESSING	IR
3.	KNOWLEDGE BASED INTEL SYSTEMS	IR
4.	C3I DATA BASE TECHNIQUES	IR
F.	RELIABILITY/MAINTAINABILITY AND COMPATIBILITY	
1.	SOLID STATE DEVICES	RB
2.	SYSTEMS/EQUIPMENT	RB
G.	COMMAND AND CONTROL	
1.	ADV C2 ENVIRONMENT	CO
2.	C2 TECHNOLOGY LAB	CO
H.	PHOTONICS	PC
1.	OPTICAL PROCESSING	DC
2.	MATERIALS & DEVICES	ES
3.	OPTICAL NETWORKS	DC
4.	OPTICAL COMPUTING	CO
5.	PHOTONICS IN-HOUSE PROGRAM	PC
I.	COMPUTATIONAL SCIENCES	
1.	SOFTWARE ENGINEERING TECHNOLOGY	CO
2.	SYSTEMS TECHNOLOGY/DISTRIBUTED SYSTEMS	CO
3.	ARTIFICIAL INTELL/KNOWLEDGE-BASED SYSTEMS	CO

TPO 5 SPECIAL PROJECTS

A. SYSTEMS/EQUIPMENT EVALUATION

- |                                    |    |
|------------------------------------|----|
| 1. HAVE NOTE                       | RB |
| 2. C3 & PROTECTIVE SYSTEMS         | RB |
| 3. TECHNIQUES & SYSTEMS EVALUATION | RB |

B.

C. COMPUTATIONAL SUPPORT

- |                                  |    |
|----------------------------------|----|
| 1. MANAGEMENT INFORMATION SYSTEM | SC |
| 2. OFFICE AUTOMATION             | SC |



## *MISSION of Rome Air Development Center*

*RADC plans and executes research, development, test and selected acquisition programs in support of Command, Control, Communications and Intelligence (C<sup>3</sup>I) activities. Technical and engineering support within areas of competence is provided to ESD Program Offices (POs) and other ESD elements to perform effective acquisition of C<sup>3</sup>I systems. The areas of technical competence include communications, command and control, battle management, information processing, surveillance sensors, intelligence data collection and handling, solid state sciences, electromagnetics, and propagation, and electronic, maintainability, and compatibility.*